U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-251 669

ASSESSMENT OF INDUSTRIAL HAZARDS WASTE PRACTICES, PAINT AND ALLIED PRODUCTS INDUSTRY, CONTRACT SOLVENT RECLAIMING OPERATIONS, AND FACTORY APPLICATION OF COATINGS

WAPORA, INCORPORATED

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY

SEPTEMBER 1975

BIBLIOGRAPHIC DATA SHEET

1. Report No. EPA/530/SW-119c

2.

PB 251 669

4. Title and Subtitle
Assessment of Industrial Hazardous Waste Practices, Paint and Allied Products Industry, Contract Solvent Reclaiming Operations, and Factory Application of Coatings

5. Report Date September, 1975-Date of Issue

6.

7. Author(s)
Francis Scofield, James Levin, Gene Beeland, Tony Laird

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
WAPORA, Inc.
6900 Wisconsin Ave., NW
Washington, D.C. 20015

10. Project/Task/Work Unit No.

11. Contract/Grant No.
68-01-2656

12. Sponsoring Organization Name and Address
U.S. Environmental Protection Agency
Office of Solid Waste Management Programs
1835 K Street, NW
Washington, D.C. 20460

13. Type of Report & Period Covered
Final

14.

15. Supplementary Notes

16. Abstracts This report describes the hazardous waste practices in the paint and coatings manufacturing industry, solvent reclaiming operations, and factory-applied coatings facilities. Approximately 3.6 million kkg (4.0 million tons) of paint and coatings were produced in the United States in 1972. Site surveys of 70 paint plants showed that raw materials packaging, cleaning wastes, dust from air pollution abatement equipment, and waste product are the major process wastes which are generated nationally at an annual rate of 396,000 kkg (436,000 tons). Approximately 95,000 kkg (105,000 tons) per year were determined by the contractor to be potentially hazardous due to either the oral toxicity or flammability of waste constituents. The vast majority of the paint industry wastes are combined in a single waste handling system and discarded in off-site landfills by private contractors. The best technology currently applied along with the technology required to provide environmentally adequate treatment and disposal for each waste stream are also provided in the report along with attendant costs. Contract operators reclaim about 270 kkg (300,000 tons) per year of waste organic solvents generated by the manufacture of paint and coatings, metals finishing, degreasing operations, etc. Distillation and evaporation units generate still bottoms as a process waste which represents roughly 25 percent of the feedstock. Most of the still bottoms is incinerated with the ash deposited in landfill. Roughly 45,000 manufacturing establishments have attendant coatings operations in this country, using about 1.7 million kkg (1.0 million tons) per year of industrial coatings and lacquers. Between 115,000 and 216,000 kkg (125,000 and 240,000 tons) per year of wastes are generated and, in general, transported by contractors to off-site landfills.

17. Key Words and Document Analysis. 17a. Descriptors

Industrial wastes	Hazardous wastes
Paints	Sludges
Waste treatment	Waste disposal
Solid wastes	Painting
	Landfills
	Lead
	Chromium
	Zinc
	Mercury
	Disposal costs

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

PRICES SUBJECT TO CHANGE

18. Availability Statement

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages 304

22. Price 9.75-2.25

i.

ASSESSMENT OF INDUSTRIAL HAZARDOUS WASTE PRACTICES, PAINT AND ALLIED PRODUCTS INDUSTRY, CONTRACT SOLVENT RECLAIMING OPERATIONS, AND FACTORY APPLICATION OF COATINGS

This final report (SW-119c) describes work performed
for the Federal solid waste management program
under contract no. 68-01-2656 to WAPORA, Inc.
and is reproduced as received from the contractor

U.S. ENVIRONMENTAL PROTECTION AGENCY

1976

NOTICE

This report has been reviewed by the Hazardous Waste Management Division, Office of Solid Waste Management Programs, EPA, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ACKNOWLEDGMENTS

Mr. Matthew A. Straus, Office of Solid Waste Management Programs, Hazardous Waste Management Division, was the EPA Project Officer responsible for monitoring this program. Mr. Francis Scofield acted as WAPORA's principal investigator, and Mr. James E. Levin was program manager. Mrs. Gene V. Beeland and Mr. Tony S. Laird were key technical staff and particpated in all phases of the program's activities.

The cooperation of the National Paint and Coatings Association through their Assistant Technical Director, Mr. Raymond Connor, is greatly appreciated. The participation of the Association's Task Force on Solid Waste, Chaired by Mr. Earl Baumhart, was also of great help.

Appreciation is also extended to Mr. Gabriel Malkin of the Federation of Societies for Coatings Technology for reviewing draft reports.

ATTENTION

AS NOTED IN THE NTIS ANNOUNCEMENT, PORTIONS OF THIS REPORT ARE NOT LEGIBLE. HOWEVER, IT IS THE BEST REPRODUCTION AVAILABLE FROM THE COPY SENT TO NTIS.

TABLE OF CONTENTS

Section Page

I. GENERAL INTRODUCTION 1

II. EXECUTIVE SUMMARY 5

III. PROJECT METHODOLOGY 19

IV. HAZARDOUS WASTE PRACTICES OF THE PAINT AND COATINGS MANUFACTURING INDUSTRY 31

Description of the Paint and Allied Products Manufacturing Industry 31

Introduction 31
Products of the Industry 31
Economic Structure 33
Future Trends and Developments 35

Paint and Coatings Industry Characterization 39

Introduction 39
Number and Distribution of Establishments Manufacturing Paint and Coatings 40
Plant Size Distribution 45
Plant Distribution by Age 45
Distribution of Products Manufactured 45
Distribution of Production 52

Paint and Coatings Manufacturing Waste Characterization 55

Introduction 55
Criteria for the Determination of a Potentially Hazardous Waste 56
Manufacturing Processes 61
Formulations 63
Industry Subcategories 64
Waste Sources 80
Raw Materials Usage 86
Potentially Hazardous Materials 96
Quantities of Potentially Hazardous Waste 101
Projected Growth in Production and Wastes 134
Summary 163

TABLE OF CONTENTS (Continued)

Section | Page

IV. (cont'd.)

Treatment and Disposal Technology 165

Introduction 165
Description of Present Treatment Technologies 166
Description of Present Disposal Technologies 168
On-Site vs. Off-Site Disposal 172
Safeguards Used in Disposal 172
Private Contractors and Service Organizations 174
Levels of Treatment and Disposal Technology for Potentially Hazardous Waste Streams 174

Cost Analysis 182

Introduction 182
Treatment and Disposal Costs 182
Summary 187

V. HAZARDOUS WASTE PRACTICES OF SOLVENT RECLAMATION OPERATIONS 189

Description of Solvent Reclamation Operations 189

Introduction 189
On-Site Reclamation at Paint Plants 189
Solvent Reclamation by Private Contractor 190
Economic Evaluation 191
Future Trends and Developments 194

Characterization of Solvent Reclamation Operations 195

Introduction 195
Number and Distribution of Facilities 195
Size Distribution 197
Age Distribution 198
Production Distribution 198
Future Trends 200

Solvent Reclaiming Waste Characterization 200

TABLE OF CONTENTS (Continued)

Section | Page

V. (Cont'd)

Introduction 200
Feedstock Sources and Quantities 200
Solvent Reprocessing Methods 201
Waste Sources 206
Waste Quantities from Solvent Reclamation 210

Treatment and Disposal Technology 211

Introduction 211
Description of Present Technology 214
Analysis of Number of Locations and Percentage of Total Wastes Disposed 215
Levels of Treatment and Disposal Technology for the Potentially Hazardous Waste Stream 215
Future Trends 217

Cost Analysis 217

VI. HAZARDOUS WASTE PRACTICES IN FACTORY-APPLIED COATINGS OPERATIONS 221

Description of Factory-Applied Coatings Operations 221

Introduction 221
Economic Structure 221
Future Trends and Developments 222

Factory-Applied Coatings Operations Characterization 224

Introduction 224
Number, Size, and Distribution of Manufacturing Plants 224
Process Distribution 225
Annual Coatings Usage 225

Factory-Applied Coatings Operations Waste Characterization 226

Introduction 226
Application Methods 226

TABLE OF CONTENTS (Continued)

Section Page

VI. (cont'd.)

Coating Technology in Specific Industries 236
Types of Coatings Used 238
Wastes as a Function of Application Method 238
Quantity of Wastes 239
Wastes as Function of Materials Coated 240

Treatment and Disposal Technology 242

Cost Analysis 242

VII. REFERENCES 245

VIII. GLOSSARY 248

LIST OF APPENDICES

A Plant Survey Report Form 257

B Detailed SIC Breakdown of Paints and Allied Products 261

C Explanation of Toxicity Ratings Excerpted from *Clinical Toxicology of Commercial Products* 263

D Potentially Hazardous Materials - Data Summary Sheets 267

E Basis for Waste Characterization Tables 271

F Private Waste Contractors and Service Organizations 275

G Contract Solvent Reclaiming Plants 279

H Properties and Uses of Hazardous Raw Materials 285

LIST OF TABLES

Table Page

1 Paint and Coatings Manufacture - Summary of Total Wastes - 1974 9

2 Paint and Coatings Manufacture - Summary of Total Wastes - 1977 11

3 Paint and Coatings Manufacture - Summary of Total Wastes - 1983 12

4 Paint and Coatings Manufacture - Levels I, II, and III Waste Treatment and Disposal Technology 14

5 Summary of Estimated Quantities of Wastes from Solvent Recovery Operations 16

6 Projected Changes in Percentage of Factory-Applied Coatings Market Held by Product Category 38

7 Estimated Number and Distribution of Establishments 41

8 Estimated Distribution of Plant Size by Employment 46

9 Estimated Distribution of Plant Ages 48

10 Plant Age Comparison Between Three Rapidly Developing States and Three with Relatively Stable Urban Populations 50

11 Estimated Distribution of Product Manufacture 51

12 Estimated Annual Production Rates in 1972 53

13 Definition of Toxicity Rating 58

14 Typical Formulation Changes to Achieve a Variety of Coatings 65

15 Estimated Pigment Usage by Paint Industry, 1972 87

16 Estimated Resin Usage by Paint Industry, 1972 91

17 Estimated Drying Oil Usage by Paint Industry, 1972 93

18 Estimated Solvent Usage by Paint Industry, 1972 94

19 Estimated Miscellaneous Materials Usage, 1972 97

LIST OF TABLES - Cont'd.

Table Page

20 Toxicity of Raw Materials Used in Surveyed Paint Plants 99

21 Constants Used and Assumptions Based on Data 104

22 Quantities of Total Paint and Coatings Industry Wastes by State - 1974 112

23 Quantities of Total Paint and Coatings Industry Wastes by EPA Region - 1974 113

24 Quantities of Waste Streams by Source - 1974 (Solvent-Thinned Trade Sales Paints) 115

25 Quantities of Wastes from Manufacture of Solvent-Thinned Trade Sales Paints by State - 1974 116

26 Quantities of Wastes from Manufacture of Solvent-Thinned Trade Sales Paints by EPA Region - 1974 117

27 Quantities of Toxic Metallic Elements in Solvent-Thinned Trade Sales Paint Wastes - 1974 118

28 Quantities of Waste Streams by Source - 1974 (Water-Thinned Trade Sales Paints) 120

29 Quantities of Wastes from Manufacture of Water-Thinned Trade Sales Paints by State - 1974 121

30 Quantities of Wastes from Manufacture of Water-Thinned Trade Sales Paints by EPA Region - 1974 122

31 Quantities of Toxic Metallic Elements in Water-Thinned Trade Sales Paint Wastes - 1974 123

32 Quantities of Waste Streams by Source - 1974 (Industrial and Non-Industrial Lacquers) 124

33 Quantities of Wastes from Manufacture of Industrial and Non-Industrial Lacquers by State - 1974 125

34 Quantities of Wastes from Manufacture of Industrial and Non-Industrial Lacquers by EPA Region - 1974 126

35 Quantities of Toxic Metallic Elements in Industrial and Non-Industrial Lacquer Wastes - 1974 128

LIST OF TABLES - Cont'd.

Table		Page
36	Quantities of Waste Streams by Source - 1974 (Factory-Applied Coatings)	129
37	Quantities of Wastes from Manufacture of Factory-Applied Coatings by State - 1974	130
38	Quantities of Wastes from Manufacture of Factory-Applied Coatings by EPA Region - 1974	131
39	Quantities of Toxic Metallic Elements in Factory-Applied Coating Wastes - 1974	132
40	Quantities of Waste Streams by Source - 1974 (Putty and Miscellaneous Paint Products)	133
41	Quantities of Wastes from Manufacture of Putty and Miscellaneous Paint Products by State - 1974	135
42	Quantities of Wastes from Manufacture of Putty and Miscellaneous Paint Products by EPA Region - 1974	136
43	Quantities of Total Paint & Coatings Industry Wastes by State - 1977	137
44	Quantities of Total Paint & Coatings Industry Wastes by State - 1983	138
45	Quantities of Total Paint & Coatings Industry Wastes by EPA Region - 1977 & 1983	139
46	Quantities of Wastes from Manufacture of Solvent-Thinned Trade Sales Paints by State - 1977	142
47	Quantities of Wastes from Manufacture of Solvent-Thinned Trade Sales Paints by State - 1983	143
48	Quantities of Wastes from Manufacture of Solvent-Thinned Trade Sales Paints by EPA Region - 1977 & 1983	144
49	Quantities of Waste Streams by Source - 1977 & 1983 (Solvent-Thinned Trade Sales Paints)	145
50	Quantities of Wastes from Manufacture of Water-Thinned Trade Sales Paints by State - 1977	146
51	Quantities of Wastes from Manufacture of Water-Thinned Trade Sales Paints by State - 1983	147

LIST OF TABLES - Cont'd.

Table		Page
52	Quantities of Wastes from Manufacture of Water-Thinned Trade Sales Paints by EPA Region - 1977 & 1983	148
53	Quantities of Waste Streams by Source - 1977 & 1983 (Water-Thinned Trade Sales Paints)	150
54	Quantities of Wastes from Manufacture of Industrial and Non-Industrial Lacquers by State - 1977	151
55	Quantities of Wastes from Manufacture of Industrial and Non-Industrial Lacquers by State - 1983	152
56	Quantities of Wastes from Manufacture of Industrial and Non-Industrial Lacquers by EPA Region - 1977 & 1983	153
57	Quantities of Waste Streams by Source - 1977 & 1983 (Industrial and Non-Industrial Lacquers)	154
58	Quantities of Wastes from Manufacture of Factory-Applied Coatings by State - 1977	156
59	Quantities of Wastes from Manufacture of Factory-Applied Coatings by State - 1983	157
60	Quantities of Wastes from Manufacture of Factory-Applied Coatings by EPA Region - 1977 & 1983	158
61	Quantities of Waste Streams by Source - 1977 & 1983 (Factory-Applied Coatings)	159
62	Quantities of Wastes from Manufacture of Putty and Miscellaneous Paint Products by State - 1977	160
63	Quantities of Wastes from Manufacture of Putty and Miscellaneous Paint Products by State - 1983	161
64	Quantities of Wastes from Manufacture of Putty and Miscellaneous Paint Products by EPA Region - 1977 & 1983	162
65	Quantities of Waste Streams by Source - 1977 & 1983 (Putty and Miscellaneous Paint Products)	164
66	Comparison of Current On-Site and Off-Site Disposal Practices	173
67	Raw Materials Packaging Waste Disposal	176
68	Disposal of Waste Products Including Spills and Spoiled Batches	177

LIST OF TABLES - Cont'd.

Table		Page
69	Wastewater Sludge Disposal	178
70	Organic Cleaning Solvent Waste Disposal	179
71	Disposal of Dust from Air Pollution Abatement Equipment	180
72	Estimated Costs for Levels of Treatment Technology	188
73	Total National Costs to the Paint Industry for Waste Disposal	188
74	Level I Treatment and Disposal Costs for a "Typical" Large Plant	188
75	Operating Costs for a Solvent Reclaiming System in a Paint Manufacturing Plant	193
76	Estimated Size Classification of Solvent Reclaiming Contractors	199
77	Analytical Characteristics of Still Bottoms Samples Collected from Solvent Reclaiming Operations	209
78	Estimated Total Waste from Solvent Reclaiming Operations	212
79	Analysis of Ash from Incinerated Still Bottoms	213
80	Solvent Reclaiming Still Bottoms Waste Disposal	216
81	Summary of Estimated Quantities of Wastes from Solvent Recovery Operations	218
82	1972 Census of Manufactures Shipments of Industrial Finishes	223
83	Total Solid Waste in an Appliance Plant	241

LIST OF FIGURES

Figure		Page
1	Number of Establishments Manufacturing Paint and Coatings Products	36
2	Estimated Distribution of U.S. Paint and Allied Products Establishments	44
3	Solvent-Thinned Paint Manufacturing Flow Diagram	66
4	Typical Solvent-Thinned Paint Formulation	67
5	Water-Thinned Paint Manufacturing Flow Diagram	69
6	Typical Water-Thinned Paint Formulation	71
7	Lacquer Manufacturing Flow Diagram	72
8	Typical Lacquer Formulation	74
9	Typical Factory-Applied Coatings Operation	75
10	Factory-Applied Coatings Formulations	76
11	Powder Coatings Manufacturing Flow Diagram	78
12	Putty Manufacturing Flow Diagram	79
13	Typical Putty Formulation	81
14	Plant Size vs. Total Waste Generation	105
15	Plant Age vs. Total Waste Generation	106
16	Modified Plant Age vs. Total Waste Generation	107
17	Summary of Total Quantities of Waste from Paint and Coatings Industry	109
18	Toxic Chemical Compounds in Waste - 1974	111
19	U.S. Distribution of Contract Solvent Reclaimers	196
20	Steam Coil Still	203
21	Scraped Surface Distillation Plant	204
22	Thin-Film Solvent Recovery Plant	205
23	Typical Solvent Recovery System	207

LIST OF FIGURES - Cont'd.

Figure		Page
24	Conventional Spray in Water-Wash Booth	227
25	Final Touchup of Locker Doors with Conventional Air-Atomized Spray Gun	228
26	Coil Coating Applying Wood Grain	231
27	Fluidized Bed Powder Coating of Pipe	233
28	Electrostatic Powder Coating	234
29	Electrocoating Bomb Fins	235

SECTION I

GENERAL INTRODUCTION

The Resource Recovery Act of 1970 (P.L. 1-512) gave the U.S. Environmental Protection Agency the general mandate to promote the demonstration, construction, and application of solid waste management and resource recovery systems which preserve and enhance the quality of air, water, and land resources. More specifically, a portion of the Act directs EPA to investigate and report on potentially hazardous waste generation and disposal techniques.

In 1972, the EPA Office of Solid Waste Management Programs (OSWMP) commissioned the following programs to determine an overview of the industrial hazardous waste problem in the United States:

A Study of Hazardous Waste Materials, Hazardous Effects and Disposal Methods, Booz-Allen Applied Research, Inc., July 1973

Recommended Methods of Reduction, Neutralization, Recovery or Disposal of Hazardous Waste, TRW Systems Group, August 1973

Public Attitudes Toward Hazardous Waste Disposal Facilities, Human Resources Research Organization, June 1973

Alternatives to the Management of Hazardous Wastes at National Disposal Sites, Arthur D. Little, Inc., May 1973

Program for the Management of Hazardous Wastes, Battelle Pacific Northwest Laboratories, July 1973

One of these studies (Program for the Management of Hazardous Wastes) was undertaken to assess hazardous waste generation in each major industrial sector. For example, the report estimated that 18,000 kkg (20,000 tons) per year of solvent-thinned paint sludge are generated along with 14,000 kkg (15,000 tons) per year of water-thinned paint sludge. The report further stated that these sludges contain chromium, cadmium, selenium, cyanide, and mercury. These materials were classified as potentially hazardous pending further study.

As a follow-up to these findings, OSMP has sponsored a number of studies to conduct more detailed assessments of the hazardous waste practices in the individual industries which were determined by Battelle to have the most significant hazardous waste disposal problems. These studies will provide information on the generation, management, treatment, disposal, and costs related to wastes considered to be "potentially hazardous." This particular study covers the paint and coatings manufacturing industry as defined by

Standard Industrial Classification (SIC) 285. This classification includes the production of water-thinned paints, solvent-thinned paints, lacquers, industrial coatings, putty, and a few miscellaneous paint-related products. SIC 285 and 2851 are identical and may be referred to interchangeably.

One objective of this program was to compile information that could be used by EPA for guidelines development work for the management of potentially hazardous wastes generated by the paint and coatings industry. To this end, data were accumulated to document:

1. Overall characteristics of the paint and coatings industry.

2. Total wastes currently generated by all segments of the industry and estimated waste generation in 1977 and 1983.

3. Potentially hazardous nature of constituents of waste streams and the total waste stream.

4. Current treatment and disposal practices for each potentially hazardous waste stream.

5. Best treatment and disposal practice for each potentially hazardous waste stream along with practices deemed environmentally adequate for each.

6. Costs of each level of treatment and disposal technology.

It should be kept in mind that no final judgments have been made on defining the classifications "hazardous wastes" or "potentially hazardous wastes." It is recognized and understood that additional information will be required on the actual fate of such materials in a given disposal environment before a final definition of "hazardous waste" evolves and is applied. For example, EPA is currently supporting other studies designed to investigate the leaching characteristics of certain waste streams identified in this report in various soil and moisture conditions.

Approximately three months after initiating this study, EPA and the contractor agreed to redirect the program objectives to include an investigation of two other industrial categories which are interrelated with paint manufacture, and to reduce the level of effort originally contemplated for paint and coatings waste disposal technology and cost analysis. This was deemed appropriate because the quantities of process wastes generated by the paint industry were found to be substantially less than those emanating from other major industrial categories -- i.e., inorganic and organic chemical industries; thus, the magnitude of the hazardous waste problem in the paint and coatings industry was not considered sufficient for a continued in-depth study.

Instead, overview studies of the solvent reclaiming industry and factory-applied coatings operations were subsequently undertaken. The objectives of these studies were to:

1. Estimate the quantity and characteristics of potentially hazardous wastes in these industries.

2. Determine the hazardous waste treatment and disposal technology used by these operations and estimate their costs.

Thus, this report is the culmination of efforts in the three basic industries: paint and coatings manufacture, solvent reclaiming, and factory-applied coatings operations. An Executive Summary covering the overall program immediately follows this introduction. After that, a discussion of the methodology used in achieving the study results is presented. Major sections on the hazardous waste practices of the three industrial activities are then presented separately. These sections are followed by a detailed reference list and glossary of terms used in the report which are specific to the paint and coatings industry.

Within the major chapter on hazardous waste practices in the paint and coatings industry, Section IV, the topics discussed include a description and characterization of the industry itself, process waste sources and quantities, and waste treatment and disposal technology, plus an analysis of treatment and disposal costs. Sections V and VI deal with the hazardous waste practices of solvent reclaiming and factory-applied coatings operations, respectively, and are organized similarly to the section on the paint and coatings industry.

SECTION II

EXECUTIVE SUMMARY

This industry study is one of a series by the Office of Solid Waste Management Programs, Hazardous Waste Management Division. The studies were conducted for information purposes only and not in response to a Congressional regulatory mandate. As such, the studies serve to provide EPA with: 1) an initial data base concerning current and projected types and quantities of industrial wastes and applicable disposal methods and costs; 2) a data base for technical assistance activities; and 3) a background for guidelines development work pursuant to Sec. 209, Solid Waste Disposal Act, as amended.

The definition of "potentially hazardous waste" in this study was developed based upon contractor investigations and professional judgment. This definition does not necessarily reflect EPA thinking since such a definition, especially in a regulatory context, must be broadly applicable to widely differing types of waste streams. Obviously, the presence of a toxic substance should not be the major determinant in defining a waste as hazardous if there are mechanisms to represent or illustrate actual effects of wastes in specified environments. Thus, the reader is cautioned that the data presented in this report constitute only the contractor's assessment of the hazardous waste management problem in these industries. EPA reserves its judgements pending a specific legislative mandate.

This report characterizes waste management practices for the paint and coatings manufacturing industry, solvent reclaiming facilities, and factory-applied coatings operations. It describes these industries in terms of plant distribution by geographic region, size, age, and products; analyzes the types of potentially hazardous wastes generated and estimates their present and projected quantities; and discusses the various methods used to treat and dispose of these waste streams and those alternative methods needed to treat, dispose, or reuse each waste stream in an environmentally adequate manner. The costs of both present and alternative disposal practices were estimated based on data collected during plant surveys and information published in other EPA reports (32, 35, 36, 37).

The paint and coatings industry was chosen by OSWMP for in-depth study because earlier work, described in the General Introduction,

Preceding page blank

identified paint manufacturing plants as sources of sludges and other wastes containing compounds of lead, chromium, mercury, and zinc (36). These wastes are ultimately disposed of on land. In addition, the likelihood that even more waste sludge will be generated as effluent limitations and standards are applied to the industry underscored the need for this study.

As the study of the paint industry progressed, it soon became apparent that there was almost complete uniformity in their practices of handling potentially hazardous wastes. It also became clear that these plants generate relatively small quantities of waste compared to some other major industries, such as petroleum refining, steel production and the production of various organic chemicals and toxic metallic compounds. At this point, EPA and the contractor agreed to redirect the balance of the study because: 1) sufficient data had been developed to provide an adequate basis upon which to characterize waste management practices in the paint industry; 2) more definitive knowledge of the total paint oriented wastes deposited on land in this country would derive from adding a study of the waste handling practices of the major reclaimers of paint industry wastes -- contract solvent recovery facilities, and the largest users of paint -- factory-applied coating operations.

The solvent reclaiming industry reprocesses about 230 million liters (60 million gal.) per year of spent solvents from several industries, including the paint and coatings industry, and generates sludges containing solvents and heavy metals. The factory-applied coatings operations are located in thousands of manufacturing installations producing numerous varieties of products. In order to cover these two areas, the level of effort originally scheduled for the study of hazardous waste disposal methods and their costs in the paint and coatings industry was substantially limited to reporting information collected during the paint plant surveys.

PAINT AND COATINGS INDUSTRY

The paint and coatings industry as defined for this study consists of the manufacture of products within Standard Industrial Classification (SIC) 285. This includes the production of exterior and interior organic solvent-thinned trade sales paint (SIC 28511 and SIC 28513), exterior and interior water-thinned trade sales paint (SIC 28512 and SIC 28514), industrial and non-industrial lacquers (SIC 28515 and SIC 28517), industrial finishes (SIC 28516), putty (SIC 28518), and miscellaneous paint products (SIC 28519).

This is an industry made up primarily of small businesses generally located in the larger urban areas close to its customers. Although the industry employs approximately 65,000 people which include about 37,000 production workers, more than half of the 1544 manufacturing establishments employ less than 20 employees each. In general, the distribution by size is relatively uniform throughout the country.

Approximately 3.6 million kkg (4 [illegible]
were produced in the United State[illegible]

The total number of plants i[illegible]
all the decrease coming in the ve[illegible]
with less than ten employees. Th[illegible]
tions where the loss of the owner [illegible]
business. Further, such small pl[illegible]
and circumstances calling for a s[illegible]
out of business. Reasons for thes[illegible]
ductions, air or water pollution [illegible]
the plant operations due to urban [illegible]
programs. Many paint companies, [illegible]
may have only one or two large an[illegible]
these customers changes his sourc[illegible]
business, this may easily cause a [illegible]

Paint and coatings productio[illegible]
blending various raw materials in[illegible]
include pigments, pigment extende[illegible]
vehicles, and miscellaneous addit[illegible]
and its end use, these additives [illegible]
fungicides, driers, or anti-skinn[illegible]
streams generated due to these ma[illegible]

1. Raw materials packag[illegible]
other packaging components in whi[illegible]
raw materials are received. An o[illegible]
in a bag when it is discarded.

2. Cleaning wastes - wa[illegible]
blending tanks, thinning tanks, a[illegible]
ing solvent is normally used seve[illegible]
the few plants where water pollut[illegible]
based cleaning wastes constitute [illegible]
treatment sludges.

3. Dust from air pollut[illegible] control equipment - particulate
from air filters used in the proc[illegible]

4. Waste finished produ[illegible] spoiled batches of paint that
cannot be reworked back into the [illegible]
cleaned up manually with sawdust [illegible]
saleable product packaged in smal[illegible]

All cleaning wastes, dust co[illegible]
are considered potentially hazard[illegible]
concentrations of compounds which [illegible]

1. Are assigned a toxic[illegible]
reference work Clinical Toxicolog[illegible]
M.N., Gosselin, R. E., Hodge, C., [illegible]
and Wilkens Co., Baltimore, 1969)

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

It will be noted that the potentially hazardous waste stream is greater than the total of the hazardous solvents and the toxic chemical compounds. This is because they are distributed in and dispersed in other materials. Cleaning rinses provide a good illustration. While 82,000 tpy (90,000 tons) are generated per year, a very large portion of this stream is water and other non-hazardous substances containing only 14,000 tpy (15,000 tons) of hazardous solvents and 500 tpy (550 tons) of toxic chemical compounds, which are not separable from the total in waste handling.

The quantity of the potentially hazardous waste stream, on the other hand, is most frequently identical to the amount of total waste. This occurs similarly because the hazardous effluent is distributed throughout the total effluent and cannot be segregated. The exception is raw materials packaging, in which bags containing toxic materials can

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]
[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] disposal of collected ash in a secured landfill. ("Incineration" means combustion in units which comply with all applicable air pollution standards. A secured landfill is one which provides impervious waste containment, monitoring, and treatment of leachate, diversion of surface water, and [illegible] of the location once filled.)

Chemically aided sedimentation and dewatering followed by disposal in a secured landfill is the Level III technology established for waste water treatment sludge. Level III technology for dust from air filters is either [illegible] disposal in a secured landfill. [illegible] packaging can be separated into non-hazardous and potentially hazardous portions. Level III then consists of incineration of [illegible] of potentially hazardous materials with the ash being sent to a

TABLE 2

PAINT AND COATINGS MANUFACTURE
SUMMARY OF TOTAL WASTES - 1977*
kkg/yr (tons/yr)
(Wet Weight)

Waste Stream	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
Cleanings	94,800(104,500)[1]	94,800(104,500)[1]	14,430(15,900)	650(700)
Raw Material Packaging	341,400(376,400)	2,000(2,250)	--	145(160)
Air Pollution Collection	1,790(1,970)	1,790(1,970)	--	90(100)
Spoiled Batches	5,470(6,030)[2]	5,470(6,030)[2]	640(700)	45(49)
Spills	6,360(7,000)[3]	6,360(7,000)[3]	86(95)	9(8)
TOTAL	449,820(495,900)[3]	110,420(121,750)[4]	15,156(16,695)	939(1017)

---

* Minor differences in totals between Tables 2, 43, and 45 are due to rounding.

[1] Includes about 28% water. [2] Includes about 5% water. [3] Includes about 6% water.
[4] Includes about 24% water.

TABLE 3

PAINT AND COATINGS MANUFACTURE
SUMMARY OF TOTAL WASTES - 1983*
kkg/yr (tons/yr)
(Wet Weight)

Waste Stream	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
Cleanings	130,000(143,300)[1]	130,000(143,300)[1]	15,420(17,000)	818(900)
Raw Material Packaging	466,800(514,700)	2,880(3,200)	--	180(200)
Air Pollution Collection	2,460(2,700)	2,460(2,700)	--	115(125)
Spoiled Batches	7,140(7,870)[2]	7,140(8,870)[2]	440(490)	57(63)
Spills	8,580(9,460)[3]	8,580(9,460)[3]	77(85)	7(7)
TOTAL	614,980(678,030)[4]	151,060(167,530)[5]	15,937(17,575)	1,177(1,295)

---

* Minor differences in totals between Tables 3, 44, and 45 are due to rounding.

[1] Includes about 32% water. [2] Includes about 6% water. [3] Includes about 8% water.
[4] Includes about 7% water. [5] Includes about 28% water.

a secured landfill. Level III technology for disposal of spoiled batches and spills also consists of incineration followed by ash disposal in a secured landfill or disposal in a secured landfill directly.

Table 4 summarizes Levels I, II, and III treatment and disposal technologies for the potentially hazardous waste streams of the paint industry.

Cost data evaluated were supplied by paint plants and represent their costs for off-site waste disposal by a contractor. These costs range from $3 to $60/kkg ($3-$50/ton)* of waste depending on the quantities handled, the nature of waste, the disposal method, and local regulations.

Costs for Level I and Level II technologies are approximately the same. Presently costs for land disposal of individual potentially hazardous waste streams range from an average of $6/kkg ($5/ton) for spoiled batches or spills to $20/kkg ($20/ton) for raw materials packaging, which has a high volume to weight ratio, and up to an average of $50/kkg ($50/ton) for waste organic solvents which require special handling. These costs for Level I and Level II technology are estimates provided by plant personnel during on-site surveys. Actual cost data were sparse. Estimated costs to achieve Level III technology for each potentially hazardous waste stream range from $20 to $60/kkg ($20-50/ton). This level of technology is not practiced in the industry and these estimates are based on previous EPA studies. (32, 35, 36, 37)

The cost of disposal of non-hazardous wastes from paint plants is in the range of $6 to $20/kkg ($5-20/ton).

The costs of waste disposal to a large paint plant producing 3.8 million liters (1.0 million gal.) per year of various products to use Level I technology are about $10,000 per year. Level II and Level III technology are marginally more expensive. Overall, the cost to the entire paint industry for using Level I technology is $10.4 million per year. This value equals about 0.2 percent of the value of shipments by the industry for 1972 ($3.9 billion). The impact of waste disposal is thus quite small.

SOLVENT RECLAMATION

Contract operators reclaim about 270,000 kkg/year (300,000 tons/yr) of the waste organic solvents generated by the manufacture of paint and coatings, metals finishing, and degreasing operations, among others. Based on a contractor search, approximately 80-100 establishments operate distillation or evaporation equipment to produce solvent which can be reused for wash-up, often by the same plants that generate the waste

---

* All cost data of greater than $10 is rounded-off to the nearest $10 increment.

TABLE 4

PAINT AND COATINGS MANUFACTURE
LEVELS I, II, AND III WASTE TREATMENT AND DISPOSAL TECHNOLOGY

Waste Stream	Level I	Level II	Level III
Raw Materials Packaging	Off-site landfill	Same as Level I	Segregation and incineration of bags containing hazardous materials. Ash to secured landfill.
Waste Products Including Spills and Spoiled Batches	Off-site landfill	Same as Level I	1. Incineration with ash to secured landfill 2. Off-site secured landfill
Wastewater Treatment Sludge	Off-site landfill	Sludge settled & sent to landfill	Chemical settling & dewatering of sludge followed by secured landfill
Dust from Air Pollution Abatement Equipment	Off-site landfill	Recycle into lower grade product	1. Recycle into lower grade product 2. Off-site secured landfill
Organic Cleaning Solvent	Off-site landfill	Solvent reprocessing with incineration of still bottoms followed by landfill disposal of ash	Level II with ash to secured landfill

solvent. There is currently little use of solvent fractionation, a process which will be required to produce reclaimed solvents capable of all of the same uses for which virgin solvents are presently employed.

Survey visits showed that distillation and evaporation units generate still bottoms as the only process waste which represents roughly 25 percent of the feedstock reprocessed -- i.e., it is estimated that 56 million liters or 55,000 kkg (15 million gal. or 60,000 tons) of still bottoms are generated annually from 230 million liters (60 million gal.) of feedstock. Current waste quantities and projections for 1977 and 1983 are shown in Table 5.

About 15 percent of the still bottoms are disposed of off-site in landfills, while another 80 percent is incinerated on-site or off-site and the ash is deposited in a landfill, usually off-site. The latter practice constitutes Level I and II disposal technology for these wastes. Level I and Level II technology costs $10-$40/kkg ($10-40/ton). There are insufficient data available to estimate with any accuracy the proportion of wastes which are incinerated on-site versus those incinerated by contractors. The limited use of still bottoms as asphalt extender or concrete block filler accounts for less than 0.1 percent of the total waste on a national basis.

Since the still bottoms or the ash from their incineration contain varying concentrations of potentially hazardous materials, such as halogenated hydrocarbons and salts of heavy metals, all of these wastes are considered to be potentially hazardous. Compliance with Department of Transportation (DOT) regulations (CFR §173.28) requires the use of new or reconditioned drums which have undergone pressure tests for the hauling or disposal of spent or reclaimed solvents which have a flash point below 38°C (100°F). It appears that in many areas these DOT regulations are not enforced and that old drums are being used to ship solvents to and from reclaimers. Strict enforcement of these regulations could add up to 13¢/liter (50¢/gal.) to the total cost of hauling solvents in drums to and from reclaimers.

Level III technology for solvent reclaiming wastes consists of still bottoms incineration followed by ash disposal on a secured landfill. This practice is expected to cost about $40/kkg ($40/ton).

With the volume of waste approximately one-third that of the saleable product, the cost of waste disposal is between 0.5 to 1.3¢ per liter (2-5¢/gal.) This plays a significant part in the overall economics of the process, considering that the wastes represent such a significant fraction of the feedstock.

FACTORY-APPLIED COATINGS OPERATIONS

There are roughly 45,000 manufacturing establishments which have attendant coatings operations in this country. These operations use about 1.7 million kkg/yr (1.9 million tons/yr) of industrial coatings

TABLE 5

SUMMARY OF ESTIMATED QUANTITIES OF WASTES FROM SOLVENT RECOVERY OPERATIONS*

kkg/yr (tons/yr)
(Wet Weight)**

	Total Waste	Waste to Landfill	Waste Incinerated	Ash to Landfill	Total Waste to Landfill
1974	55,000(60,000)	7,600(8,400)	47,000(52,000)	940(1030)	8,500(9,400)
1977	72,000(80,000)	10,000(11,000)	62,500(69,000)	1,240(1,370)	11,200(12,300)
1983	97,000(107,000)	13,500(15,000)	83,400(92,500)	1,660(1,830)	15,200(16,700)

---

*All of these wastes are considered potentially hazardous.

**Note: Wet Weight = Dry Weight

and lacquers and employ various coating application techniques. The quantity of waste generated is largely a function of the application method used. The most widely used technique is the spray booth which is also one of the least efficient methods in terms of the amounts of waste coating generated which requires disposal. Others, such as roller and powder coating produce little or no waste since all non-adhering coating is collected and recycled.

Based on data accumulated during survey visits, it is estimated that between 115,000 and 216,000 kkg/yr (125,000 and 240,000 ton/yr) of paint waste are generated from factory-applied coatings operations on a dry weight basis. The paint wastes are included in a total waste stream from the painting area of between 300,000 and 1,000,000 kkg/yr (320,000 and 1,100,000 tons/yr). This total waste stream includes large quantities of paper, air filters, wash solvents, containers, etc. During the survey visits, it was observed that most plants mix their paint wastes with the various other process wastes generated. These wastes are normally stored in open trash containers on the plant site.

Level I treatment and disposal technology for factory-applied coatings wastes is contractor disposal in a landfill. While the data in hand do not permit precise identification of Level II and III technology, the following observations based on the character of the wastes can be made:

> Segregated waste coatings which contain no toxic or flammable constituents are suitable for disposition in a sanitary landfill. Other wastes which contain such materials in small quantities should be handled as potentially hazardous wastes. A large portion of those streams can be incinerated with the potentially toxic ash going to a secured landfill. The non-combustible portion of this waste, -- i.e., wastewater treatment sludge -- should be dewatered and disposed of in a secured landfill.

The reported costs for disposal of paint wastes in surveyed plants varied from $4 to $100/kkg ($4 to $100/ton), depending on the nature of the coating material, the disposal method, and the factors included in the cost assessment. The higher values represent the total cost of waste management while lower figures are simply charges made by landfill operators for depositing solid material in their landfill.

SECTION III

PROJECT METHODOLOGY

The basic methodology used for this research project was the collection of data from the industries involved -- paint and allied products manufacture, solvent reclaiming operations, and factory application of coatings. Other information sources included the U.S. Bureau of the Census, the National Paint and Coatings Association, the Federation of Societies for Coatings Technology, raw materials manufacturers, pertinent literature, and related EPA reports (32, 35, 36, 37).

The information gathered was extrapolated by methods outlined within the report to describe the national character of these three industrial activities in terms of geographic distribution, size and age range, nature and quantity of wastes, and the practices utilized for waste treatment and disposal and their associated costs.

HAZARDOUS WASTES PRACTICES OF THE PAINT AND ALLIED PRODUCTS INDUSTRY

Industry Characterization

The first task of this portion of the project was to characterize the paint and coatings industry as embraced in Standard Industrial Classification 285 by state, EPA region, and nationally according to the 4-digit SIC code -- i.e., solvent-thinned paints, water-thinned paints, factory-applied finishes, putty, and miscellaneous products. The 1972 Census of Manufactures provided the primary source of information. It groups over 1550 establishments in SIC 285 and provided the basis for many of the breakdowns by regions and states. The Census tabulations do not, however, show the number of plants when only a few establishments are located in those states nor do they segregate by 4-digit SIC category. As a result, the figures used in both of these cases are all estimates. They were derived through industry directories, trade associations, contractor experience, and plant surveys.

The 1972 Census of Manufactures also identifies the number of plants with 20 or less production workers by geographic region and, in some cases, by state. The figures reported for individual states were used, although it was necessary to estimate the less-than-20 employee plants for the other states as well as the state breakdown of larger plants. These were also derived from industry directories; trade

Preceding page blank

association questionnaires; WAPORA plant surveys; and in-house knowledge. Since apparently all sources did not use the same definition of "employees," care was necessary in interpreting sometimes conflicting data. The breakdown into SIC categories according to size is based entirely on contractor estimates and extrapolations.

Available relevant information on plant age is sparse. The Bureau of the Census does not report on the age of plants, and, although this kind of information was sought in a recent National Paint and Coatings Association questionnaire (13), the results were weighted with more returns from the larger and newer plants and do not represent a good random sample of the industry. Consequently, the estimated distribution required by EPA was necessarily extrapolated from the usable information on plant age developed by the questionnaire and by 71 plant surveys. It was derived as follows:

1. The surveyed plants in each state were placed in their respective age ranges. The total number of surveyed plants in each age bracket was divided by the total number of plants surveyed in that state. Each fraction was then multiplied by the number of plants in the state and then weighted by a factor placing more importance on state and local trends. The reason for this was that state and local variables such as site incentives (tax, business climate, etc.), environmental considerations, availability of personnel, and market proximity would exert an influence on locating a plant in a particular state and locality and thus deserved more weight.

2. The total number of surveyed plants in each age bracket in the region embracing the state was divided by the total number of surveyed plants in that region. This ratio was then multiplied by the total plants in the state.

3. The total number of surveyed plants in each age bracket in the nation was divided by the total number of plants. The ratio was then multiplied by the total number of plants in the state. The resultant was then multiplied by a weighted factor giving less importance to the national results.

4. The numbers from Steps 1, 2, and 3 were added and divided by three to determine the total number in each age range in the state.

The estimated distribution of plants by separate product is essentially the same as distribution by SIC, a product-oriented classification. Varnishes and stains were added to those enumerated above to complete the industry's product line. All estimates are again based on Census data, trade association questionnaires, industry directories, and contractor experience.

It can be assumed that at least a small amount of varnishes of one kind or another are made by practically all coatings manufacturers, either by cooking resins and oils together or (in the vast majority of cases) by simple cold-blending of purchased materials. To arrive at this distribution, the number of varnish manufacturers was assumed to be identical with the number of solvent-thinned paint producers due to the small difference between varnish and solvent-thinned paint formulations as was found during the survey visits.

The definition of "stains" is obscure. The products so described may range from a dye dissolved in a solvent to a thin paint, and there is no general agreement as to when a product ceases to be a paint and becomes a stain. Creosote stains are generally produced by the coal tar chemicals industry rather than the paint industry.

There are no Census figures available on this classification. The numbers of estimated stain manufacturers represent 10 percent of the solvent-thinned paint manufacturers (rounded off to the nearest whole number). This assumption is based primarily on contractor knowledge and experience.

The number of lacquer plants was derived from production figures modified by contractor knowledge.

There are no directly pertinent state and regional data available to support a breakdown by quantities of production. However, it was possible to arrive at the dispersion breakdown as follows:

The 1972 Census of Manufactures gives national production in millions of gallons for SIC categories 28511 through 28517. The value of product shipments is provided by Census region and some larger states, as well as for the country as a whole, broken down by SIC classification. Assuming that value of production is distributed among the various products in each region and state in the same ratio as it is distributed in the country as a whole it is possible to estimate value of production and thus quantities produced, by region and state. The nature of dispersion in the paint industry is such that this conclusion is likely to be valid.

However, it is necessary in some cases to group smaller states together. Census tabulations do not provide individual state totals when to do so might disclose individual plant data. For example, in the New England division (EPA Region I), state totals are given for Massachusetts, Rhode Island, and Connecticut. The total for Maine, New Hampshire, and Vermont may be obtained by subtracting this from the total for the New England Division. These states are, therefore, grouped together. Where groupings are necessary they were placed within the boundaries of EPA regions rather than Census regions.

The quantity by state was estimated by multiplying the dollar value for each state (or group of states) by the ratio of total gallons produced to total dollar value in the nation. The value for product categories was determined by dividing quantities given for each product in the 1972 Census by the total national quantity, then multiplying the ratio by the quantity for the state.

No method for approximating the break-down of production in SIC

groups 28518, 28519, or 28510 (pa [illegible]
fied by kind) is available. The [illegible]
percent of the total; 28519 is 10 [illegible]
The total of the three is 22.4 pe [illegible]
all SIC 285 materials, a number c [illegible]
by weight, rather than volume. [illegible]

Waste Characterization

At the outset of the waste [illegible]
a list of potentially hazardous m [illegible]
comprised of substances proposed [illegible]
felt also warranted consideration [illegible]
basis of potential toxicity or fl [illegible]
do not exhibit other hazardous to [illegible]
or biological propoerties. [illegible]

The list was incorporated i [illegible]
use in on-site paint plant visits [illegible]
kinds of information from each pl [illegible]
copy of the format appears in App [illegible]

Next, a list of candidate p [illegible]
ing industry directories, trade a [illegible]
contractor experience. When fina [illegible]
made, age, size, geographic locat [illegible]
and a range in each category was [illegible]
ing approximately 5.9 percent of [illegible]
veyed on site. They range in age [illegible]
two to 340 employees. In additio [illegible]
approximately 10 other individual [illegible] representing roughly 56 percent
of the 20 largest paint manufactu [illegible]
of the industry's production.

Most surveyed plants were a [illegible]
total production (within ±6 perce [illegible]
reported, the accuracy of which v [illegible]
tem used and other factors; the [illegible]
estimated to be in the ±10 percen [illegible]
also available on some waste stre [illegible]
others. It is estimated that the [illegible]
in the range of +5 percent to -20 [illegible]

The quantities of wastes ge [illegible]
trapolated from the survey data b [illegible]
on the basis of numbers of plants [illegible]
tion. These extrapolations inclu [illegible]
tially hazardous waste streams, a [illegible]
tuents. The 1974 waste estimates [illegible]

[illegible]

Estimation of Total National Waste Quantities

[illegible]

Spills — [illegible] plants representing 5.7 percent of the industry's production, totaled 15,900 liters (4200 gal.). It was assumed that the [illegible]

[illegible] plants can be extrapolated to 41 Mg (45 tons) from this source each year.

Cleanings — The total cleaning stream is approximated to be 66.6 million liters (17.6 million gal.) of spent organic solvents and wash water and 380 Mg (419 tons) of solids. Solvents account for 40.0 million liters (10.6 million gal.) of the total fluid content. It is estimated that 11.4 million liters (3.0 million gal.) of this are reclaimed leaving 28.6 million liters (7.6 million gal.) for disposal.

It is somewhat more difficult to estimate the solids content of this stream since precise analytical data for evaluating this parameter are not generally available. In addition, because individual waste streams are not segregated it was necessary to arrive at the solids which derive solely from cleaning operations indirectly by calculating total solids and deducting those attributable to spills and spoiled batches. Estimates were based on industry experience; the following factors were assumed:

1. Since water is an inexpensive solvent, the solid content in water washing will be low.

2. Where wastewater treatment is practiced, the sludges included in solid waste will have a high solid content.

[illegible]

[illegible]

[illegible]

[illegible] included [illegible] steel or plastic pails [illegible] drums [illegible] The [illegible] this waste stream is estimated at [illegible] annually and consists of bags in which toxic pigments and other hazardous materials are delivered. This figure is derived as follows:

Approximately [illegible] of such materials are [illegible] calculated on the basis of an average bag weight of [illegible]

Since pails are easily cleaned and, according to industry [illegible] are most often recycled [illegible] they are not included in the potentially hazardous waste stream.

[illegible]

total non-water solvents used in the paint and coatings industry as defined by SIC 285 is 1469 million liters (388 million gal.) per year, of which 940 million liters (250 million gal.) fall within the definition of hazardous solvents. It has been assumed that the latter constitute the same proportion -- i.e., 65 percent -- of the solvents in the waste. This assumption is probably high since the hazardous solvents are in general more volatile and are more likely to be lost to the atmosphere. This percentage has been used, however, because of a lack of any comprehensive quantification data to support an alternative appraoch.

Thus, total hazardous solvents in the waste are calculated to be 17 million liters (4.5 million gal.) per year, or 65 percent of 26.5 million liters (7 million gal.). The accuracy of these figures is estimated to be in the range of +0 to -30 percent.

Descriptions of manufacturing processes and typical formulations utilized in the various SIC classifications and projections of future trends in products specific to SIC category involved the literature, industry information, and contractor knowledge as well as the plant surveys.

Treatment and Disposal Technology

The treatment and disposal practices of the industry as a whole were extrapolated from the data on waste disposal practices of surveyed plants. While the base sample is small, the results may be considered to be relatively accurate as compared to waste quantity extrapolations because of the uniformity of disposal practices within the industry. Thus, Level I technology -- technology currently employed by typical facilities -- was easily and conclusively established.

Level II technology -- the best process from an environmental and health standpoint currently in use in at least one location -- was also dictated, except in the case of organic wash solvents, to a large extent by the lack of viable alternatives in use by the industry. Several current methods for handling wash solvents were available for consideration as Level II technology.

Level III technology -- technology necessary to provide adequate health and environmental protection which may include pilot or bench scale processes -- was influenced by the fact that the degree of toxicity of some of the waste materials, and their ultimate environmental effects, cannot be established without qualification within the framework of today's knowledge of their behavior under all conditions. Thus, in terms of economic necessity, as more such information is developed, Level III may be found to be more restrictive than necessary or desirable in some cases.

Due to the altered scope of the project, the actual practices of off-site land disposal operators -- private or public -- were not investigated on site and the limited descriptions offered at the paint plants must be substituted. Similarly, other factors which are in the purview of the land disposal agent rather than the paint plant such as energy requirements, implementation time for each level of technology, and monitoring techniques and facilities were not covered.

Waste Disposal Costs

Cost figures gathered during the plant surveys plus those available in the literature were analyzed to establish costs as applicable to the services provided to individual paint plants. They do not include any breakdown of the cost structure of contractors' operations. Cost data from related EPA reports were used to determine the capital and operating costs of Levels II and III technology implementation (32, 35, 36, 37).

HAZARDOUS WASTE PRACTICES OF SOLVENT RECLAMATION

During this portion of the project a list of about 75 contract solvent reclaimers was compiled from data gathered during the study of the paint and coatings industry, from manufacturers of distillation equipment, and the yellow pages of metropolitan telephone directories. In addition, a number of paint plants which recover solvents on-site were included.

To gather detailed information on as many types of these operations as possible within the scope of the added contract element, 16 plant visits were made. These included four paint plants, two plants which recover chlorinated hydrocarbons exclusively, and 10 others which reclaim a mixture of solvents. Data from two paint plants previously surveyed which provided information on solvent reclamation were also used. A geographical cross section was achieved by visits to major industrial areas such as Newark, New Jersey; Chicago, Illinois; and Cleveland, Ohio; as well as less industrialized locations in the Carolinas, Indiana, Kentucky, and Texas.

In view of the fact that many of these plants occupy a highly competitive position in industrial areas and that some have been repeatedly subjected to various kinds of studies, the overall degree of cooperation was outstanding. Some plant owners and operators were very cooperative and spent considerable time showing survey personnel over their premises and providing detailed information. Only two plants contacted refused to supply any information and declined to entertain the possibility of a plant visit. Between these extremes were a number of people who met with us and cordially supplied as much information as they felt they could without divulging proprietary information. No waste samples were obtainable from proprietary operations and data on quantities of feedstock and waste were sparse.

Geographical areas not covered by actual site visits were surveyed by telephone inquiry. Data from these surveys are less reliable and not as complete, but the aim was to identify any significant variation in technology or mode of operation in these areas. Information on 11 plants was gathered in this manner.

Samples of still bottoms were gathered at as many plants as possible for analysis for hazardous properties. At plants where more than one recovery operation was in progress a sample was obtained from each process. A total of 16 different samples was gathered and evaluated.

It must be emphasized that the general reliability of data generated from these samples is minimal since in all cases they were grab samples representative of the operation at that time only and not a composite representative of total operation. They can only serve as an indicator of the character of solvent recovery wastes. In many cases these samples do not represent the final waste from a solvent reclaiming plant since in practice the still bottoms go directly to an incinerator from which there is little waste.

Two manufacturers of solvent recovery equipment were visited during the study to discuss technology, future developments, availability of equipment, and cost data. Both manufacturers were extremely helpful in providing this information and in identifying solvent reclaimers. Information on a third type of distillation equipment was supplied by another manufacturer after a telephone request.

HAZARDOUS WASTE PRACTICES OF FACTORY-APPLIED COATING OPERATIONS

The major users of factory-applied coatings were identified from the 1972 Census of Manufactures which reports end uses of these products by quantity and dollar value. Because of the very large number of individual operations in this general category, variously estimated in the tens of thousands, those uses which account for the largest volumes of coatings were singled out for the closest scrutiny, along with the use of powdered coatings, a relatively new technology and one reported to be environmentally beneficial. The following types of coatings operations evolved:

Automotive
Furniture
Container
Appliance
Farm Machinery
Coil
Concrete
Decorative Metal
Job
Powdered

Next a cognizant group of trade associations and one trade publication were contacted for assistance in selecting operations for site visits which could be considered typical of those within a segment. These included:

National Forest Products Association
Chemical Coaters Association
Accoustical and Board Products Association
National Coil Coaters Association
National Concrete Masonry Association
Hardwood Plywood Association
Southern Furniture Manufacturers Association
Industrial Finishing Magazine

Finally, two automotive and two furniture finishing operations were selected for survey plus one in each of the remaining segments for a total of 13. Cooperation was excellent and a great deal of useful information was elicited.

Based on these data, a description of the amount of wastes typically generated by the various application processes was developed and representative disposal methods (Level I technology) were identified. No extrapolations to industry-wide waste generation performance were undertaken because the limited scope of this investigation did not reveal sufficient information on the wide variation in size among the large number of factory-applied coatings operations or the distribution of coating processes employed. Levels II and III disposal technology were not identified because coatings wastes are presently seldom segregated from wastes produced from a whole series of production processes, and with the data in hand it is not possible to isolate these technologies for coating wastes alone.

SECTION IV

HAZARDOUS WASTE PRACTICES OF THE PAINT AND COATING MANUFACTURING INDUSTRY

DESCRIPTION OF THE PAINT AND ALLIED PRODUCTS MANUFACTURING INDUSTRY

Introduction

In this section, the term "paint" is defined as it is used in this report and the uses of the products of the paint and coatings industry are identified. "Trade sales products" and "industrial finishes," designations applied to broad product categories by the industry and the Department of Commerce, are also defined. The Standard Industrial Classifications (SIC) which segregate various products for statistical purposes according to end use and/or composition are introduced. These classifications will be used in this report to present and compare statistics describing various segments of this industry, their production, and wastes.

The economic structure of the industry in terms of plant size, age, and geographic distribution is generally outlined; these factors are addressed in more detail later in this section. Future growth trends and developments in raw material and product changes are also forecast.

Products of the Industry

Definition of Paint and Allied Products Industry

Within the scope of this study, the "paint and allied products industry" is defined as those manufacturing facilities covered in the 1972 Census of Manufactures by SIC 285 which defines them as: "Establishments primarily engaged in manufacturing paints (in paste and ready-mixed form); varnishes; lacquers; enamels and shellac;* putties, wood fillers, and sealers; paint and varnish removers; paint brush cleaners; and allied paint products." SIC 285 does not include pigment or resin manufacture,

---

*Shellac is a form of the lac resin, manufactured in India, and describes the appearance of the solid material -- i.e., shell lac, as opposed to button lac or stick lac. No shellac, so far as the contractor is aware, is manufactured in the United States.

Preceding page blank

or the manufacture of printing ink, artists' colors, calking compounds and sealants, or roof coatings (bituminous).

The industry covered by SIC 285 is frequently referred to in this report as the "paint and coatings" industry, the current terminology.

Definition of Paint

In common usage the word "paint" is subject to various interpretations. In its narrowest definition, paint is defined as a pigmented product such as wall paint, exterior house paint, masonry paint, and traffic paint. Other coatings are referred to as enamel, undercoater, primer (industrial), sealer, varnish, lacquer, filler, stain, etc. (2). However, in spite of movements to adopt other nomenclature, "paint" remains established as the general term for all of these coatings (2)(3) and will be generally used in this manner in this report. When narrower allied product classes are specifically discussed, they will be so identified.

Use of Paint

Paint is applied to wood, metals, concrete, and other substrates in virtually all of the myriad of current uses of these materials. In some form it is a universal substance in its applications in dwellings, places of work, furnishings, transportation, tools, appliances, other structures, and objects of daily use.

While paint is generally acknowledged to protect and decorate, it can also serve many other useful purposes. Lighter colors with higher reflectance values can enhance lighting; white paint promotes cleanliness by increasing the visibility of dirt and a hard glossy paint surface is easier to clean than more porous ones; safety is furthered through painted traffic indicators, fire retardance of construction materials, color coding of machinery parts and pipes (2)(3), and non-skid paints. Outside paint may aid interior temperature control -- light colors reflect and darker colors absorb heat -- and special paints are also used to preserve wood and to provide electrical insulation or conductance, military camouflage, luminescence, and grain simulation (wood, hammered metals, leather, wrinkled textures, etc.) (2)(3).

Classification of Products

The products of the paint and allied products industry are classified in several different ways. Perhaps the most frequently used classification scheme by the industry is defined as "trade sales products" and "industrial finishes." Trade sales products, as defined by the Department of Commerce, are "stock-type commodities generally distributed through wholesale-retail channels." These are sold in small packages --

.2 to 7.6 liters (1/2 pt. to 2 gal.) to the public in paint, hardware and variety stores (4). Industrial finishes are "products specifically formulated to meet the conditions of application and use of the product to which applied and are generally applied as part of the manufacturing process." These highly specialized products are sold in large quantities to industries such as the automobile, aircraft, furniture, and electrical appliance (4). Maintenance paints sold for the upkeep of industrial and public structures and equipment fall within the Commerce Department's definition of trade sales products (2).

The most commonly used classification by the government is the Standard Industrial Classification. This was established by the Executive Office of the President, Office of Management and Budget, and is as follows (5):

28511 - Exterior Oil Type Trade Sales Paint Products
28512 - Exterior Water Type Trade Sales Paint Products
28513 - Interior Oil Type Trade Sales Paint Products
28514 - Interior Water Type Trade Sales Paint Products
28515 - Trade Sales Lacquers
28516 - Industrial Product Finishes, Except Lacquers
28517 - Industrial Lacquers
28518 - Putty and Allied Products
28519 - Miscellaneous Paint Products
28510 - Paints and Allied Products, Not Specified by Kind

Narrower SIC breakdowns are shown in Appendix B.

The National Paint and Coatings Association (NPCA) has recently categorized the various products to reflect new technologies, the increasing use of which may influence the characteristics of this industry's wastes in the future (6). In addition to conventional solvent-thinned coatings, these classifications include 1)coatings reformulated to comply with air pollution control restrictions on the use of photochemically reactive solvents; 2) water-soluble and water emulsion coatings in which non-reactive organic solvents account for 30 percent or less of total volatile content; 3) coatings containing 70 percent solids content (by volume) or higher, including finishes formulated for ultraviolet curing; and 4) dry powder coatings.

The last four are termed "emerging technologies" and offer opportunities for pollution reduction due to the smaller quantities of solvents involved as compared with the amounts used in conventional coatings and the less hazardous nature of those which will be used (6).

Economic Structure

The paint industry is comprised of about 1200 companies which operate more than 1500 manufacturing establishments (7). Overall the industry employs approximately 65,000 people, of whom roughly 37,000 are production workers (5). It is primarily an industry of small businesses since about half the paint manufacturing facilities in the country have fewer than 20 employes and only a handful have more than 500 production workers. One reason for this is that the cost of transporting raw materials in bulk is much less than transporting finished paints in cans or drums so it is usually more economical to make the products as close to the customer as possible. Thus, even the larger companies tend to scatter their operations among several small plants close to a broader range of customers rather than consolidate them in one area. Another reason is that, by comparison with other manufacturing operations, little equipment is used and only a small capital investment is required. Up to now, the economies of scale have not been significant. Today, however, the emergence of new raw materials has increased the complexity of paint technology and the minimum economic size is increasing in scale. Total capital expenditures during 1972 were $85.7 million, a 21 percent increase over the capital expenditures of $70.7 million in 1967 (5).

The result of the economics of transportation is that plants tend to concentrate near high density populations. Only four states (North Dakota, South Dakota, Hawaii, and Wyoming) do not appear to have any paint manufacture within their borders. Several other states of relatively small population such as Arkansas, Idaho, and Nevada have only one or two plants. There are more than a hundred in some larger states, usually grouped around centers of population and industry. Although there are several large companies in the paint industry (five firms are believed to have annual sales of over $100 million each), these are all multi-plant companies, and expansion is usually achieved by adding additional plants close to other markets rather than by expansion of existing plants.

The distribution of plants by size appears to be relatively uniform throughout the United States. There are apparently no especially high concentrations of small plants in any specific areas, except possibly in areas of rapid population growth such as Florida, California, and Texas. In some cases, what appears to be an exception in distribution patterns turns out to be a peculiarity of geography. New Jersey, for example, has a much higher proportion of large plants than does New York, but, in this instance, it means that factors affecting a large plant serving the New York metropolitan area such as state and local tax laws are more favorable in northern New Jersey than in New York City. Small plants are less affected by some of these considerations. In addition, most of the large industrial paint users in the New York City area, such as petroleum refineries, can manufacturing, etc., are located in New Jersey.

Approximately 2.98 billion liters (786 million gal.) of paint and coatings were produced in the United States in 1972 at a value of $3.875 billion. Roughly 75 percent of this production occurred in EPA Regions

I, II, III, IV & V -- the Eastern sector of the nation. In the past, the paint and coatings industry has demonstrated a steady and reliable growth rate. Between 1958 and 1971, the dollar value of paint sales increased at an average annual rate of 4.5 percent as compared to 6.8 percent for the Gross National Product (GNP) and 1.3 percent for population. Over this same period, the quantity of paint sold grew by an average 3.0 percent per year (7).

The age of plants in the paint industry runs the entire gamut. In general, as might be expected, there is a slightly higher concentration of new plants in those areas that have experienced recent, rapid growth, as noted above, and more old plants in states embracing established urban areas such as Massachusetts, New York, Pennsylvania, and Maryland.

Future Trends and Developments

Figure 1 shows that a decline in the number of establishments manufacturing paint and coatings has taken place since the early 1960's and is projected to continue into the late '70's. There are several reasons for this.

One is that many of the older paint plants were or are located downtown in metropolitan areas. With the advent of more restrictive fire or nuisance ordinances many have been faced with the choice of moving or closing. In other cases, a small operation is sold to a larger company who purchases it only for its community goodwill and the local marketing ability of the seller. In these cases the plant is often closed.

Another reason is that there was a great number of small paint plants established during and shortly after World War I. In situations where these were essentially one-man operations, the owner's age would have become a factor in either selling or closing the business during the last decade.

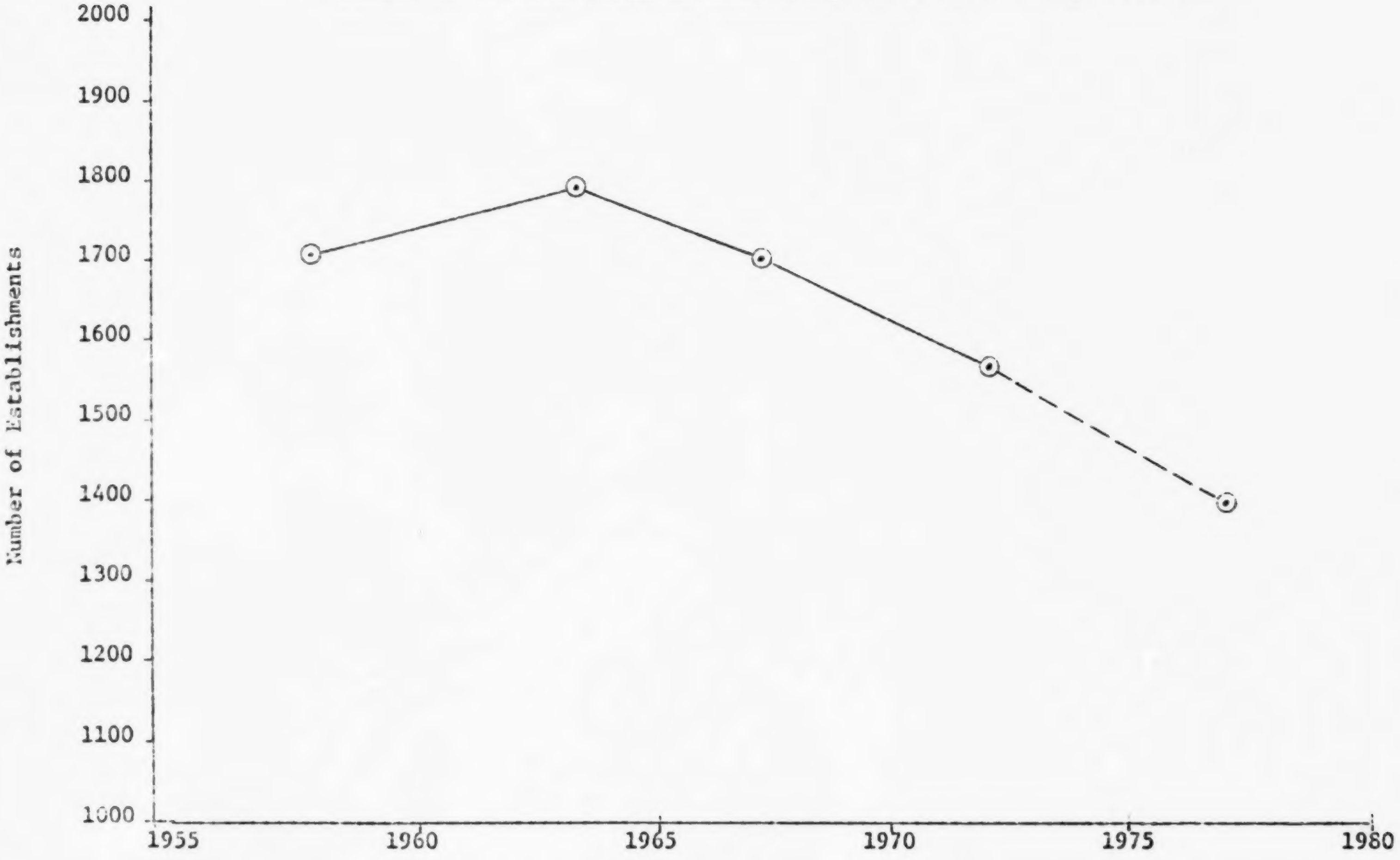
While the contractor has found no evidence of plant closings which are directly attributable to environmental control requirements, this tendency could develop in the future. Under certain conditions, such as small operations which are already marginally profitable or noneconomic, the cost of pollution control regulation may hasten a predestined closure.

This subject has been studied under another EPA contract (8) and it was found that with the application of proposed effluent standards (9) the major factors relating to economic impact affecting shutdown decisions would be:

Ratio of treatment cost to net income
Cash flow including treatment costs
Ratio of treatment investment to fixed assets

FIGURE 1

Number of Establishments Manufacturing Paint and Coatings Products



Source: 1972 Census of Manufactures Industry Series Preliminary Report. Extrapolation based on Economic Analysis of Proposed Effluent Guidelines.

Degree of integration (paint/pigment/resin manufacture)
Emotional commitment
Ownership (private or multi-company)

This study concludes that, based on these criteria, 323 plants have a high probability of closure (8). This figure is recognized as a maximum and the number of plants in this high range is reduced to 243 when those with a high emotional commitment to remain in business are eliminated.

The total number of production employees in the industry peaked in 1970 at nearly 40,000 (10). A decline of nearly 2000 took place by 1971 and a further, but smaller, reduction from 1971 to 1972 placed the latter total at about 37,000. A small, but steady, decline may be predicted with a degree of certainty to continue at least through this decade. As "strong-arm" labor becomes more expensive there will be increasing use of various expedients to reduce personnel costs. Some of these are the use of forklift trucks, automated equipment, and predispersed pigments.

The recent drop in number of plants and total production employees has not been accompanied by a reduction in value of industry shipments which increased by $1 billion from 1967 to 1972. C. H. Kline & Co. predicts that sales will increase at an annual rate of 5.1 percent through 1980 (7).

Table 6 illustrates the changes which are expected to take place by 1977-1980 in the percentage of the total industrial coatings market held in 1972-73 by the NPCA product categories enumerated above (11). It can be seen that the most dramatic drop is predicted in solvent-thinned industrial coatings as improvements are incorporated in water-thinned and other industrial paints (11). This trend will be furthered by the significant economies to be gained by reduced use of organic solvents. In fact, the push to reduce or eliminate solvents has been responsible for hastening the development of new coatings systems such as emulsions, electro-deposited coatings, powder coatings, and others (12). While such systems accounted for only about 13 percent of industrial finishes in 1973, their use is expected to triple by 1980. One exception is in the coating of wood products. Many wood furniture manufacturers do not see a suitable water-based coating for their products on the horizon because of the inherent effect of water on wood grain. However, it is understood that water-thinned materials are presently being used on decorative wood paneling in two industrial operations.

It is predicted that solvent shortages will inhibit the growth of exempt solvent coatings (11). "Exempt," or conforming, solvents are those which meet Los Angeles County, California, Rule 66 and similar standards which place limits on the photochemically reactive characteristics of solvents which may be used.

The production of water-thinned trade sales paints will steadily

TABLE 6

PROJECTED CHANGES IN PERCENTAGE OF FACTORY-APPLIED COATINGS MARKET HELD BY PRODUCT CATEGORY (10)

Type of Coating	1972-73	1977-80
Conventional solvent-thinned coatings	64%	18%
Exempt solvent-thinned coatings	26%	35%
Water-borne with less than 20% exempt solvents	6%	30%
High-solids (80% solids by volume or more)	1%	11%
Powder coatings	3%	6%

increase due to their popularity with "do-it-yourself" painters and other factors enumerated later in Section IV.

Nitrocellulose lacquers are predicted to give way to thermo-setting or oxidizing coatings. Cooked varnishes are gradually disappearing and cold-blended varnishes will be more widely used in trade sales coatings. Putty competes with calking compounds, very similar products which are not currently included in SIC 285. Improvements in putty formulation may tend to move more of its production into the calking compound classification.

Growth trends and anticipated changes in raw materials usage and finished products are discussed in considerable detail later in this report.

PAINT AND COATINGS INDUSTRY CHARACTERIZATION

Introduction

In this section the industry is characterized by SIC classification according to:

1. Number and distribution of establishments manufacturing paint and coatings
2. Size distribution in terms of number of employees
3. Age distribution
4. Product manufacture distribution
5. Distribution in quantities produced

This classification was selected for use in characterizing the industry over the other classification schemes discussed earlier in this section because: 1) the Census of Manufactures provides at least limited data according to these classifications which is not amenable to other breakdowns; 2) these classifications provide logical and orderly product groupings; and 3) they also lend uniformity of presentation among concurrent hazardous waste studies.

The basis used for extrapolating available information by state and EPA region to arrive at national totals as required by EPA is described. Several sources of information were used in addition to the U.S. Census, the most reliable and up-to-date being the surveys performed on 70+ plants during the course of the study. Other sources included returns from two recent questionnaires (13, 14) sent to the industry for other studies and major industry directories (7, 15).

Some SIC categories were grouped together for this presentation because the differences in waste generated by them were not sufficiently significant to warrant separate characterization. No distinction is made between interior and exterior paints, although solvent-thinned and water-thinned paints are segregated because of the differences in their waste characteristics. Approximately 60 percent of the solvent-thinned trade sales paints are classified as exterior (28511) as compared to about one-third of the water-thinned paints (28512) used for this purpose.

Because of their similarities in formulations, processing, and waste characteristics, industrial and non-industrial lacquers are grouped together. Trade sales lacquers constitute about 25 percent and industrial finish lacquers about 75 percent of the total.

Number and Distribution of Establishments Manufacturing Paint and Coatings

Table 7 shows the total estimated number and distribution of establishments manufacturing paint and allied products in the United States by state, EPA region, and nationally. It also shows similar breakdowns by SIC product category as discussed above. The column breakdowns do not, of course, "add" to the national total since many plants manufacture multiple products which fall within more than one SIC.

It was necessary to use some estimates to overcome discrepancies in the available data pertaining to distribution of plants and it should be noted that as the numbers of estimated establishments in Table 7 get smaller, the potential for relative accuracy probably declines. This is true of the data on paint plants in all SIC categories in states containing only a few establishments since the Census of Manufactures does not segregate the data in these cases. In addition, the number of putty manufacturers is very small in all states and these numbers may be in error by perhaps one or two plants per state. Recent activity in opening or closing plants, which is easily accomplished in some cases, could seriously affect the estimate.

The final column dealing with the production by state of miscellaneous products falling within the SIC 285 paint classification should be similarly used with caution. It is felt, however, that the national totals for both putty and miscellaneous products manufacturers are reasonably accurate.

The breakdowns by SIC are to a degree supported by the following rationales:

1. Most companies manufacturing trade sales products make both solvent- and water-thinned paints. A few companies, such as those specializing in marine coatings, make only solvent-thinned paints, and a few plants (mostly small ones) only produce water-thinned paints. About 10 percent of the companies make only factory-applied coatings

TABLE 7

SIC 2851 PAINT AND ALLIED PRODUCTS
ESTIMATED NUMBER AND DISTRIBUTION OF ESTABLISHMENTS

STATES	EPA REGION	TOTAL NO.	SIC 28511 & 28513 SOLVENT THINNED PAINTS	SIC 28512 & 28514 WATER THINNED PAINTS	SIC 28515 & 28517 INDUSTRIAL AND NON-INDUSTRIAL LACQUERS	SIC 28516 FACTORY APPLIED FINISHES	SIC 28518 PUTTY COMPOUND AND ALLIED PRODUCTS	SIC 28519 MISCELLANEOUS PAINT PRODUCTS
1 AL	IV	9	7	7	2	6	1	1
2 AK	X	1	1	1	0	0	0	0
3 AZ	IX	7	7	7	3	5	1	3
4 AR	VI	7	5	5	3	5	1	1
5 CA	IX	213	187	188	60	172	2	13
6 CO	VIII	11	8	8	3	7	1	1
7 CT	I	12	10	10	5	10	1	2
8 DE	III	5	4	4	2	3	0	0
9 DC	III	1	1	1	0	0	0	0
10 FL	IV	69	68	68	20	55	1	2
11 GA	IV	37	32	32	11	29	2	3
12 HI	IX	0	0	0	0	0	0	0
13 ID	X	2	2	2	1	2	0	0
14 IL	V	143	122	124	41	115	2	4
15 IN	V	30	25	25	9	24	1	1
16 IA	VII	10	9	9	4	8	2	3
17 KS	VII	6	4	4	1	2	0	0
18 KY	IV	23	19	19	7	18	1	2
19 LA	VI	13	11	11	2	8	1	2
20 ME	I	2	2	2	0	0	0	0
21 MD	III	27	22	22	8	22	1	2
22 MA	I	52	47	48	13	43	2	4
23 MI	V	63	58	58	19	54	1	2
24 MN	V	24	20	20	7	19	1	2
25 MS	IV	3	1	1	1	2	0	1
26 MO	VII	59	51	51	17	47	3	6
27 MT	VIII	1	1	1	0	1	1	1
28 NB	VII	2	1	1	0	2	0	0
29 NV	IX	1	1	1	0	0	0	0
30 NH	I	2	1	1	1	2	0	0

TABLE 7 - Cont'd.

SIC 2851 PAINT AND ALLIED PRODUCTS
ESTIMATED NUMBER AND DISTRIBUTION OF ESTABLISHMENTS

STATES	EPA REGION	TOTAL NO.	SIC 28511 & 28513 SOLVENT THINNED PAINTS	SIC 28512 & 28514 WATER THINNED PAINTS	SIC 28515 & 28517 INDUSTRIAL AND NON-INDUSTRIAL LACQUERS	SIC 28516 FACTORY APPLIED FINISHES	SIC 28518 PUTTY COMPOUND AND ALLIED PRODUCTS	SIC 28519 MISCELLANEOUS PAINT PRODUCTS
31 NJ	II	149	129	130	43	119	5	10
32 NM	VI	1	1	1	0	1	0	0
33 NY	II	145	127	128	41	116	1	2
34 NC	IV	17	15	15	8	14	1	3
35 ND	VIII	0	0	0	0	0	0	0
36 OH	V	97	83	83	27	78	5	10
37 OK	VI	11	9	9	2	6	1	2
38 OR	X	16	14	14	4	13	0	1
39 PA	III	66	58	60	22	55	5	10
40 RI	I	9	7	7	3	7	0	0
41 SC	IV	5	4	4	0	2	0	0
42 SD	VIII	0	0	0	0	0	0	0
43 TN	IV	19	16	16	5	15	1	2
44 TX	VI	86	74	75	24	69	1	4
45 UT	VIII	2	2	2	1	2	1	1
46 VT	I	4	2	2	1	2	0	0
47 VA	III	18	15	15	2	14	2	4
48 WA	X	25	22	22	7	20	1	2
49 WV	III	3	2	2	0	2	0	0
50 WI	V	31	26	26	9	25	1	2
51 WY	VIII	0	0	0	0	0	0	0
NATIONAL		1544	1333	1342	439	1221	51	109
EPA REGION								
	I	81	69	70	23	64	3	6
	II	294	256	258	84	235	6	12
	III	120	102	104	34	96	8	16
	IV	182	162	162	54	141	7	14
	V	393	334	336	112	315	11	21
	VI	118	100	101	31	89	4	9
	VII	77	65	65	22	59	5	9
	VIII	14	11	11	4	10	3	3
	IX	221	195	196	63	177	3	16
	X	44	39	39	12	35	1	3

and about five percent specialize in putties, other related products, or lacquers only.

2. Most large companies, and many smaller ones, make either factory-applied coatings, or industrial maintenance paints (SIC 28516), or both although they represent only a small part of the production of many of these plants.

3. Lacquer manufacture is often segregated from other paint operations due to the flammability of the solvents used. For this and other reasons many of the smaller companies do not make lacquers.

4. Putties, paint removers, and other allied products are often produced by plants that make no other products.

The table illustrates, as expected, that the concentration of paint plants is directly related to urban density, both established and developing. States embracing nine of the 10 largest metropolitan areas are among the 12 states containing the greatest number of plants, collectively representing about 77 percent of the paint manufacturing establishments in the country. Among the other four, Florida, Georgia, and Texas represent both new population growth and increased industrialization, while Ohio is a heavily populated area of several older urban centers. The twelve states, in descending order of number of plants, are as follows:

California
New Jersey
New York
Illinois
Ohio
Texas
Florida
Michigan
Pennsylvania
Missouri
Massachusetts
Georgia

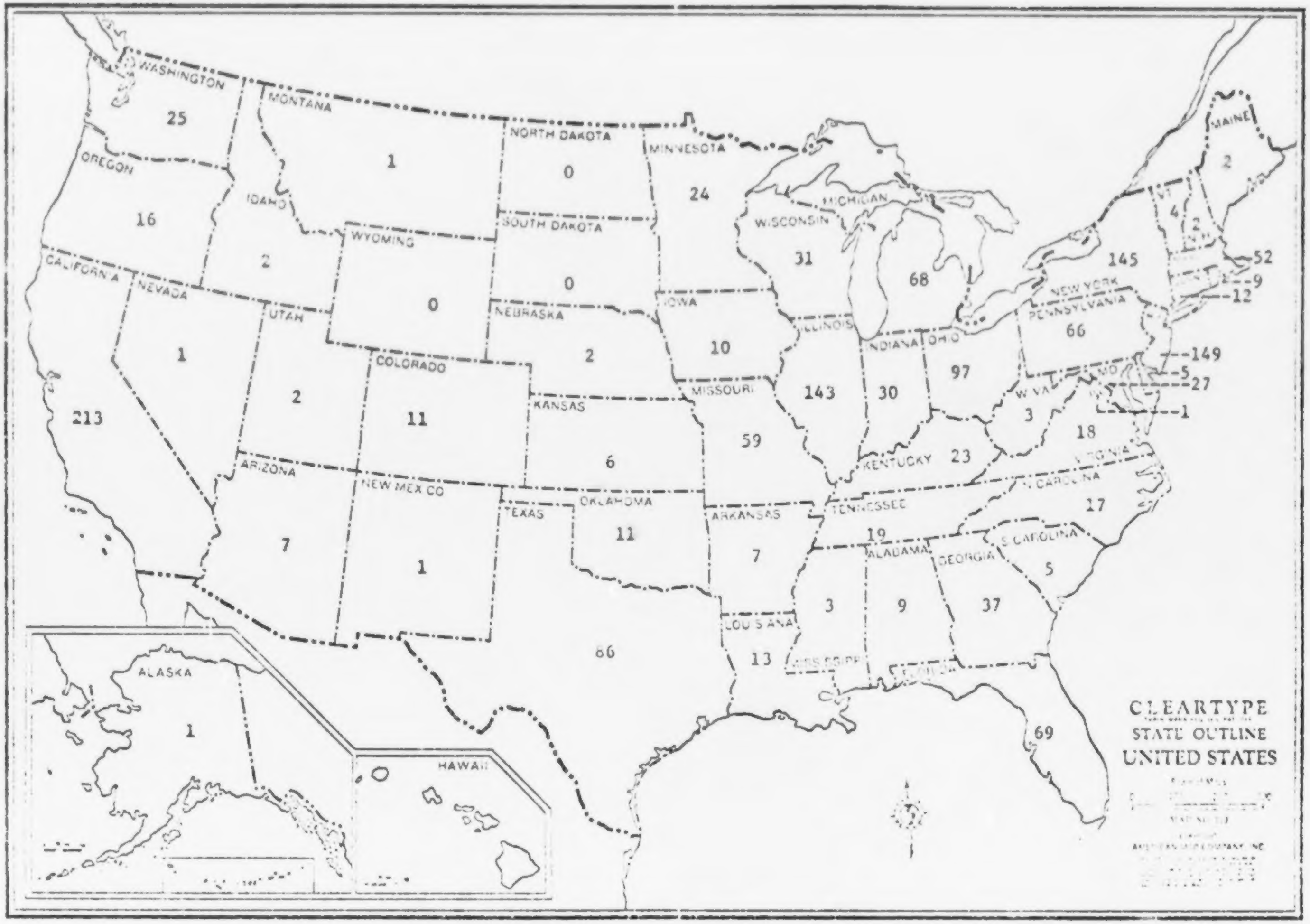
The District of Columbia metropolitan area, the tenth largest in the country, does not alter this pattern. While Washington, D.C. itself, which supports little industrialization, has only one paint plant, the neighboring states of Maryland and Virginia together account for 45 establishments.

At the other end of the scale, no paint manufacture was found in Hawaii, North Dakota, South Dakota, and Wyoming, as noted earlier. The number of establishments per state is shown graphically in Figure 2.

The pattern established for total paint operations does not vary

FIGURE 2

Estimated Distribution of U.S. Paint and Allied Products Establishments


WASHINGTON
25
OREGON
16
CALIFORNIA
213
NEVADA
1
IDAHO
2
MONTANA
1
WYOMING
0
UTAH
2
COLORADO
11
ARIZONA
7
NEW MEXICO
1
NORTH DAKOTA
0
SOUTH DAKOTA
0
NEBRASKA
2
KANSAS
6
OKLAHOMA
11
TEXAS
86
MINNESOTA
24
IOWA
10
MISSOURI
59
ARKANSAS
7
LOUISIANA
13
WISCONSIN
31
ILLINOIS
143
MICHIGAN
68
INDIANA
30
OHIO
97
KENTUCKY
23
TENNESSEE
19
MISSISSIPPI
3
ALABAMA
9
GEORGIA
37
FLORIDA
69
S CAROLINA
5
N CAROLINA
17
VIRGINIA
18
W VA
3
MD
PENNSYLVANIA
66
NEW YORK
145
VT
4
2
MAINE
2
52
9
12
149
5
27
1
ALASKA
1
HAWAII
CLEARTYPE
STATE OUTLINE
UNITED STATES

appreciably when the breakdo[illegible] estimated. The more populated areas still re[illegible]duction in every case except putty and miscellane[illegible]ket patterns may vary substantially from time to time in these two categories, a thorough study of which was not within the scope of this project.

Plant Size Distribution

Table 8 shows the distribution of paint plants by size in terms of the number of employees per establishment. The ranges identified are from 1-20, 21-50, 51-100, and 100+. Further breakdowns are not required in view of the very small number of plants employing in excess of 100 employees.

The pattern developed by the table is that the largest numbers of plants in each category employ between one and 20 persons. The numbers of plants generally decline in the larger employment ranges, frequently descending sequentially as the employment range rises. The few exceptions, such as certain categories of plants in Illinois, Michigan, and Pennsylvania, are not sufficiently significant to alter the general observation that smaller plants are in the majority in this industry. In Michigan, for instance, a number of medium size plants are explained by the substantial amount of production of automobile coatings, a large but very localized user. Again, columns in Table 8 do not "total" due to overlapping between SIC classifications.

Plant Distribution by Age

Table 9 shows the distribution of paint plants by age. This parameter is a highly variable consideration in that older structures may not have been consistently used for paint manufacture, older paint plants may have been updated to the performance of news ones, etc. For purposes of this table, plant age is defined, as nearly as this is possible, as the number of years during which paint has been manufactured at a specific location.

The age of paint plants is nearly evenly distributed over the past fifty years, reflecting both a gradual growth rate for the industry and an orderly replacement of plants which close down for various reasons. States such as Texas, Florida, and California which have rapid overall industrial growth show only a slightly larger incidence of very new plants than states like Massachusetts, Pennsylvania, and Illinois where population has been more stable in the last decade. Table 10 shows an across-the-board comparison of plant ages in these six states demonstrating this fact.

Distribution of Products Manufactured

Table 11 shows the estimated distribution of paint and coatings manufacture by separate product such as water-thinned paints, solvent-thinned paints, varnish, stains, lacquers, industrial finishes, putty and glazing,

TABLE 8

SIC 2851 PAINT AND ALLIED PRODUCTS
ESTIMATED DISTRIBUTION OF PLANT SIZE BY EMPLOYMENT

STATES	EPA REGION	SIC 28511 & 28513 SOLVENT THINNED PAINTS				SIC 28512 & 28514 WATER THINNED PAINTS				SIC 28515 & 28517 IND.& NON-IND.LACQUERS				SIC 28516 FACT.APPLIED FINISHES				SIC 28518 PUTTY & ALLIED PROD.				SIC 28519 MISC. PAINT PRODUCTS			
		1-20	21-50	51-100	100+	1-20	21-50	51-100	100+	1-20	21-50	51-100	100+	1-20	21-50	51-100	100+	1-20	21-50	51-100	100+	1-20	21-50	51-100	100+
1 AL	IV		1	1	1	4	1	1	1	1	0	1	0	3	1	1	1	1	0	0	0	1	0	0	0
2 AK	X	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 AZ	IX	4	2	1	0	4	2	1	0	2	1	0	0	2	2	1	0	1	0	0	0	2	1	0	0
4 AR	VI	3	1	0	1	3	1	0	1	1	1	0	1	2	2	0	1	1	0	0	0	1	0	0	0
5 CA	IX	113	34	22	13	119	34	22	13	40	10	6	4	112	31	19	10	1	1	0	0	5	5	2	1
6 CO	VIII	3	2	1	2	3	2	1	2	2	0	1	0	3	1	1	2	1	0	0	0	1	0	0	0
7 CT	I	6	1	0	1	8	1	0	1	5	0	0	0	6	1	0	1	1	0	0	0	2	0	0	0
8 DE	III	3	0	1	0	4	0	0	0	1	0	1	0	2	0	1	0	0	0	0	0	0	0	0	0
9 DC	III	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 FL	IV	54	10	4	0	54	10	4	0	12	6	2	0	42	9	4	0	1	0	0	0	2	0	0	0
11 GA	IV	16	7	6	3	16	7	6	3	5	3	2	1	14	6	6	3	2	0	0	0	3	0	0	0
12 HI	IX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 ID	X	2	0	0	0	2	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
14 IL	V	61	31	10	20	62	32	10	20	23	9	3	6	56	29	10	20	1	1	0	0	2	1	1	0
15 IN	V	16	3	3	3	16	3	3	3	3	2	2	2	15	3	3	3	1	0	0	0	1	0	0	0
16 IA	VII	3	3	2	1	3	3	2	1	1	1	1	1	3	2	2	1	2	0	0	0	3	0	0	0
17 KS	VII	2	1	0	1	2	1	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0
18 KY	IV	4	9	3	3	4	9	3	3	0	1	1	5	2	7	3	6	1	0	0	0	2	0	0	0
19 LA	VI	5	5	1	0	5	5	1	0	0	1	1	0	4	3	1	0	1	0	0	0	2	0	0	0
20 ME	I	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 MD	III	8	6	1	7	8	6	1	7	3	2	1	2	6	6	2	8	0	1	0	0	0	2	0	0
22 MA	I	27	9	8	3	28	9	8	3	6	4	2	1	27	9	3	4	2	0	0	0	3	1	0	0
23 MI	V	31	9	16	2	31	9	16	2	9	5	4	1	27	9	16	2	1	0	0	0	2	0	0	0
24 MN	V	12	5	2	1	12	5	2	1	2	2	2	1	11	5	2	1	1	0	0	0	2	0	0	0
25 MS	IV	1	0	0	0	1	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	1	0	0	0
26 MO	VII	26	12	8	3	28	12	8	3	5	4	5	3	26	11	7	3	2	1	0	0	4	2	0	0
27 MT	VIII	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0
28 NB	VII	1	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
29 NV	IX	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 NH	I	1	0	0	0	1	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0

TABLE 8 - Cont'd.

SIC 2851 PAINT AND ALLIED PRODUCTS
ESTIMATED DISTRIBUTION OF PLANT SIZE BY EMPLOYMENT

STATES	EPA REGION	SIC 28511 & 28513 SOLVENT THINNED PAINTS 1-20	21-50	51-100	100+	SIC 28512 & 28514 WATER THINNED PAINTS 1-20	21-50	51-100	100+	SIC 28515 & 28517 IND.& NON-IND.LACQUERS 1-20	21-50	51-100	100+	SIC 28516 FACT.APPLIED FINISHES 1-20	21-50	51-100	100+	SIC 28518 PUTTY & ALLIED PROD. 1-20	21-50	51-100	100+	SIC 28519 MISC. PAINT PRODUCTS 1-20	21-50	51-100	100+
31 NJ	II	72	35	14	8	73	34	14	9	25	8	5	5	54	32	19	13	3	1	1	0	6	2	2	0
32 NM	VI	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
33 NY	II	93	25	7	2	93	26	7	2	29	6	4	2	89	15	9	3	1	0	0	0	2	0	0	0
34 NC	IV	6	5	3	1	6	5	3	1	1	2	3	2	3	4	4	3	1	0	0	0	3	0	0	0
35 ND	VIII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[illegible]	0	0
36 OH	V	40	21	14	8	40	21	14	8	15	6	4	2	38	19	13	8	2	2	1	0	4	3	2	1
37 OK	VI	6	2	1	0	6	2	1	0	0	1	1	0	4	1	1	0	1	0	0	0	1	1	0	0
38 OR	X	6	7	1	0	6	7	1	0	2	2	0	0	6	6	1	0	0	0	0	0	1	0	0	0
39 PA	III	28	15	4	11	30	15	4	11	11	5	2	4	27	14	4	10	4	1	0	0	7	2	1	0
40 RI	I	5	1	0	1	5	1	0	1	3	0	0	0	5	1	0	1	0	0	0	0	0	0	0	0
41 SC	IV	3	1	0	0	3	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
42 SD	VIII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43 TN	IV	9	4	2	1	9	4	2	1	3	1	1	0	8	4	2	1	1	0	0	0	2	0	0	0
44 TX	VI	39	14	14	7	40	14	14	7	14	4	4	2	35	14	13	7	1	0	0	0	2	0	1	1
45 UT	VIII	1	0	0	1	1	0	0	1	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	1
46 VT	I	1	1	0	0	1	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
47 VA	III	5	5	5	0	5	6	4	0	2	0	0	0	5	5	4	0	1	1	0	0	2	1	1	0
48 WA	X	12	5	4	1	12	5	4	1	3	2	1	1	11	4	4	1	1	0	0	0	2	0	0	0
49 WV	III	1	0	1	0	1	0	1	0	0	0	0	0	[illegible]	0	1	0	0	0	0	0	0	0	0	0
50 WI	V	17	5	2	2	17	5	2	2	5	2	1	1	16	5	2	2	1	0	0	0	2	0	0	0
51 WY	VIII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NATIONAL		762	298	165	108	770	300	163	109	237	93	61	48	676	266	162	117	38	9	3	1	73	21	11	4
EPA REGION																									
	I	43	13	8	5	44	13	8	5	15	5	2	1	46	17	5	3	3	0	0	0	5	1	0	0
	II	165	60	21	10	166	60	21	11	54	14	9	7	139	43	25	15	4	1	1	0	8	2	2	0
	III	45	26	13	18	48	27	11	18	17	7	4	6	41	25	18	18	5	3	0	0	9	5	2	0
	IV	97	37	19	9	97	37	19	9	22	14	10	8	74	22	20	14	7	0	0	0	14	0	0	0
	V	177	74	47	36	178	75	47	36	57	26	16	13	163	70	46	36	7	3	1	0	13	4	3	1
	VI	53	22	17	8	54	22	17	8	15	7	6	3	45	20	16	8	4	0	0	0	5	1	1	1
	VII	34	16	10	5	34	16	10	5	6	5	6	5	31	14	9	5	4	1	0	0	7	1	0	0
	VIII	4	2	2	3	4	2	2	3	3	0	1	0	4	1	2	3	1	0	1	1	1	0	1	1
	IX	123	36	23	13	124	36	23	13	42	11	6	4	124	33	20	20	1	1	0	0	7	6	1	1
	X	21	12	5	1	21	12	5	1	6	4	1	1	25	20	5	1	1	0	0	0	5	0	0	0

TABLE 9

SIC 2851 PAINT AND ALLIED PRODUCTS
ESTIMATED DISTRIBUTION OF PLANT AGES

		SIC 28511 & 28513				SIC 28512 & 28514				SIC 28515 & 28517				SIC 28516				SIC 28518				SIC 28519			
		SOLVENT THINNED PAINTS				WATER THINNED PAINTS				IND.& NON-IND.LACQUERS				INST.APPLIED FINISHES				PUTTY & ALLIED PROD.				MISC. PAINT PRODUCTS			
		AGE RANGE (YRS)				AGE RANGE (YRS)				AGE RANGE (YRS)				AGE RANGE (YRS)				AGE RANGE (YRS)				AGE RANGE (YRS)			
STATES	EPA REGION	0-10	11-20	21-50	50+	0-10	11-20	21-50	50+	0-10	11-20	21-50	50+	0-10	11-20	21-50	50+	0-10	11-20	21-50	50+	0-10	11-20	21-50	50+
1 AL	IV	2	1	3	1	2	1	3	1	0	1	1	0	1	1	3	1	0	0	1	0	0	0	1	0
2 AK	X	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 AZ	IX	2	1	3	1	2	1	3	1	1	0	1	1	1	1	2	1	0	0	1	0	1	0	1	1
4 AR	VI	1	1	3	0	1	1	3	0	1	0	2	0	1	1	3	0	0	0	1	0	0	0	1	0
5 CA	IX	64	31	60	32	64	31	61	32	21	10	19	10	59	28	56	29	1	0	1	0	5	2	4	2
6 CO	VIII	2	1	3	2	2	1	3	2	1	0	1	1	1	1	3	2	0	0	1	0	0	0	1	0
7 CT	I	1	2	6	1	1	2	6	1	0	1	3	1	1	2	6	1	0	0	1	0	0	1	1	0
8 DE	III	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0
9 DC	III	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 FL	IV	16	24	19	9	16	24	19	9	5	7	6	2	12	20	15	8	0	1	0	0	0	1	1	0
11 GA	IV	9	7	11	5	9	7	11	5	3	2	4	2	8	7	9	5	1	0	1	0	1	1	1	0
12 HI	IX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 ID	X	0	0	2	0	0	0	2	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0
14 IL	V	27	22	38	35	27	22	39	36	9	7	13	12	26	20	36	33	1	0	1	0	1	1	1	1
15 IN	V	7	3	7	8	7	3	7	8	2	1	3	3	6	3	7	8	0	0	0	1	0	0	0	1
16 IA	VII	2	1	3	3	2	1	3	3	1	0	2	1	2	1	3	2	0	0	1	1	1	0	1	1
17 KS	VII	1	0	2	1	1	0	2	1	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0
18 KY	IV	3	2	6	8	3	2	6	8	2	1	2	2	3	2	6	7	0	0	0	1	0	0	1	1
19 LA	VI	6	2	2	1	6	2	2	1	1	0	1	0	5	1	2	0	1	0	0	0	1	0	1	0
20 ME	I	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 MD	III	5	5	8	4	5	5	8	4	2	2	3	1	5	5	8	4	0	0	1	0	0	1	1	0
22 MA	I	6	14	19	8	6	14	20	8	1	4	6	2	5	14	18	6	0	1	1	0	1	1	2	0
23 MI	V	15	7	20	16	15	7	20	16	5	2	7	5	14	6	19	15	0	0	1	0	0	0	1	1
24 MN	V	6	4	6	4	6	4	6	4	2	1	2	2	6	4	5	4	1	0	0	0	1	0	1	0
25 MS	IV	0	0	1	0	0	0	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	1	0
26 MO	VII	13	6	16	16	13	6	16	16	4	2	6	5	12	5	15	15	1	0	1	1	1	1	2	2
27 MT	VIII	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0
28 NB	VII	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
29 NV	IX	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 NH	I	1	0	0	0	1	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0

Table 9 - Cont'd.

SIC 2851 PAINT AND ALLIED PRODUCTS
ESTIMATED DISTRIBUTION OF PLANT AGES

		SIC 28511 & 28513				SIC 28512 & 28514				SIC 28515 & 28517				SIC 28516				SIC 28518				SIC 28519			
		SOLVENT THINNED PAINTS				WATER THINNED PAINTS				IND.& NON-IND.LACQUERS				FACT.APPLIED FINISHES				PUTTY & ALLIED PROD.				MISC. PAINT PRODUCTS			
	EPA	AGE RANGE (YRS)				AGE RANGE (YRS)				AGE RANGE (YRS)				AGE RANGE (YRS)				AGE RANGE (YRS)				AGE RANGE (YRS)			
STATES	REGION	0-10	11-20	21-50	50+	0-10	11-20	21-50	50+	0-10	11-20	21-50	50+	0-10	11-20	21-50	50+	0-10	11-20	21-50	50+	0-10	11-20	21-50	50+
31 NJ	II	35	13	48	33	35	13	49	33	11	5	16	11	32	12	44	31	2	0	2	1	3	1	4	2
32 NM	VI	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
33 NY	II	16	13	55	43	17	13	55	43	5	4	18	14	15	12	50	39	0	0	1	0	0	0	1	1
34 NC	IV	6	2	5	2	6	2	5	2	3	1	3	1	5	2	5	2	1	0	0	0	2	0	1	0
35 ND	VIII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36 OH	V	17	19	24	23	17	19	24	23	5	6	8	8	15	17	23	23	1	1	1	2	2	2	3	3
37 OK	VI	4	1	3	1	4	1	3	1	1	0	1	0	3	1	2	0	1	0	0	0	1	0	1	0
38 OR	X	4	1	8	1	4	1	8	1	1	0	3	0	3	1	8	1	0	0	0	0	0	0	1	0
39 PA	III	11	11	21	15	12	11	22	15	4	4	8	6	11	10	20	14	1	1	2	1	2	2	4	2
40 RI	I	1	2	3	1	1	2	3	1	0	2	1	0	1	2	3	1	0	0	0	0	0	0	0	0
41 SC	IV	1	1	1	1	1	1	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
42 SD	VIII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43 TN	IV	4	4	6	2	4	4	6	2	1	1	2	1	4	4	6	1	0	0	1	0	1	0	1	0
44 TX	VI	16	27	27	4	16	28	27	4	6	8	9	1	15	25	25	4	0	0	1	0	1	1	2	0
45 UT	VIII	0	0	1	1	0	0	1	1	0	0	1	0	0	0	1	1	0	0	1	0	0	0	1	0
46 VT	I	1	0	1	0	1	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0
47 VA	III	6	4	3	2	6	4	3	2	1	0	1	0	5	4	3	2	1	0	1	0	2	1	1	0
48 WA	X	3	1	12	6	3	1	12	6	1	0	4	2	2	1	12	5	0	0	1	0	0	0	2	0
49 WV	III	1	0	1	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
50 WI	V	[illegible]	8	6	5	5	8	6	5	1	3	2	3	5	6	6	8	0	0	0	1	0	1	0	1
51 WY	VIII	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NATIONAL		322	243	470	298	324	244	475	299	103	75	164	97	291	221	436	273	13	4	25	9	27	17	46	19
EPA REGION																									
	I	10	18	30	11	10	18	31	11	2	7	11	3	10	18	23	8	0	1	2	0	1	2	3	0
	II	51	26	103	76	52	26	104	76	16	9	34	25	47	24	94	70	2	0	3	1	3	1	5	3
	III	24	22	34	22	25	22	35	22	8	6	13	7	23	20	33	20	2	1	4	1	4	4	6	2
	IV	41	41	52	28	41	41	52	28	14	13	19	8	34	37	46	24	2	1	3	1	4	2	7	1
	V	77	63	103	91	77	63	103	92	24	20	35	33	72	56	96	91	3	1	3	4	4	4	6	7
	VI	26	31	35	6	28	32	35	6	9	8	13	1	25	28	32	4	2	0	2	0	3	1	5	0
	VII	16	7	22	20	16	7	22	20	5	2	9	6	14	6	22	17	1	0	2	2	2	1	3	3
	VIII	2	1	5	3	2	1	5	3	1	0	2	1	1	1	5	3	0	0	3	0	0	0	3	0
	IX	66	32	63	34	66	32	64	34	22	10	20	11	60	29	58	30	1	0	2	0	6	2	5	3
	X	7	2	23	7	7	2	23	7	2	0	8	2	5	2	22	6	0	0	1	0	0	0	3	0

TABLE 10

PLANT AGE COMPARISON BETWEEN THREE RAPIDLY DEVELOPING STATES AND THREE WITH RELATIVELY STABLE URBAN POPULATIONS (FRACTION IN AGE RANGE)

	Years			
	0-10	11-20	21-50	50+
Texas	.22	.36	.37	.05
Florida	.24	.35	.28	.13
California	.35	.16	.32	.17
Massachusetts	.13	.30	.40	.17
Pennsylvania	.19	.19	.36	.26
Illinois	.22	.18	.31	.29

TABLE 11

SIC 2851 PAINT AND ALLIED PRODUCTS
ESTIMATED DISTRIBUTION OF PRODUCT MANUFACTURE

STATES	EPA REGION	SOLVENT THINNED PAINTS	WATER THINNED PAINTS	VARNISH	STAINS	LACQUERS	INDUSTRIAL FINISHES	PUTTY & GLAZING	OTHER PRODUCTS
1 AL	IV	7	7	7	1	2	6	1	1
2 AK	X	1	1	1	0	0	0	0	0
3 AZ	IX	7	7	7	1	3	5	1	1
4 AR	VI	5	5	5	1	3	5	1	1
5 CA	IX	187	188	187	19	60	172	2	13
6 CO	VIII	8	8	8	1	3	7	1	1
7 CT	I	10	10	10	1	5	10	1	2
8 DE	III	4	4	4	0	2	3	0	0
9 DC	III	1	1	1	0	0	0	0	0
10 FL	IV	66	68	68	7	20	55	1	2
11 GA	IV	32	32	32	3	11	29	2	3
12 HI	IX	0	0	0	0	0	0	0	0
13 ID	X	2	2	2	2	1	2	0	0
14 IL	V	122	124	122	12	41	115	2	4
15 IN	V	25	25	25	3	9	24	1	1
16 IA	VII	9	9	9	1	4	8	2	3
17 KS	VII	4	4	4	0	1	2	0	0
18 KY	IV	19	19	19	2	7	18	1	2
19 LA	VI	11	11	11	1	2	8	1	2
20 ME	I	2	2	2	0	0	0	0	0
21 MD	III	22	22	22	2	8	22	1	2
22 MA	I	47	48	47	5	13	43	2	4
23 MI	V	58	58	58	6	19	54	1	2
24 MN	V	20	20	20	2	7	19	1	2
25 MS	IV	1	1	1	0	1	2	0	1
26 MO	VII	51	51	51	5	17	47	3	6
27 MT	VIII	1	1	1	0	6	1	1	1
28 NE	VII	1	1	1	0	0	2	0	0
29 NV	IX	1	1	1	0	0	0	0	0
30 NH	I	1	1	1	0	1	2	0	0
31 NJ	II	129	130	129	13	43	119	5	10
32 NM	VI	1	1	1	0	0	1	0	0
33 NY	II	127	128	127	13	41	116	1	2
34 NC	IV	15	15	15	2	8	14	1	3
35 ND	VIII	0	0	0	0	0	0	0	0
36 OH	V	83	83	83	8	27	78	5	10
37 OK	VI	9	9	9	1	2	6	1	2
38 OR	X	14	14	14	1	4	13	0	1
39 PA	III	58	60	58	6	22	55	5	10
40 RI	I	7	7	7	0	3	7	0	0
41 SC	IV	4	4	4	0	0	2	0	0
42 SD	VIII	0	0	0	0	0	0	0	0
43 TN	IV	16	16	16	2	5	15	1	2
44 TX	VI	74	75	74	7	24	69	1	4
45 UT	VIII	2	2	2	0	1	2	1	1
46 VT	I	2	2	2	0	1	2	0	0
47 VA	III	15	15	15	2	2	14	2	4
48 WA	X	22	22	22	2	7	20	1	2
49 WV	III	2	2	2	0	0	2	0	0
50 WI	V	26	26	26	3	9	25	1	2
51 WY	VIII	0	0	0	0	0	0	0	0
NATIONAL		1333	1342	1333	135	439	1221	51	109
EPA REGION									
I		69	70	69	6	23	64	3	6
II		256	258	256	26	84	235	6	12
III		102	104	102	10	34	96	8	16
IV		161	162	161	17	54	141	7	14
V		334	336	334	34	112	315	11	21
VI		100	101	100	10	31	89	4	9
VII		65	65	65	6	22	59	5	9
VIII		11	11	11	1	4	10	3	3
IX		195	196	195	20	63	177	3	14
X		39	39	39	5	12	35	1	3

and other products. Essentially, this table also shows the distribution of plants by manufacturing process because the processes used in this industry are not highly variable, and the minor differences which do occur are attributable to product requirements. For example, production of a pigmented material requires grinding or dispersion while the manufacture of a non-pigmented material does not.

Table 11 shows that the number of plants manufacturing solvent-thinned paints, water-thinned paints, and varnish is identical in almost every state by virtue of the fact that the majority of installations which makes one of them produces all three. So to the extent that these estimates may be valid, there are only nine plants which manufacture water-thinned products exclusively -- one each in California, Massachusetts, New Jersey, New York, and Texas, and two in Illinois and Pennsylvania.

Most industrial finishes are also manufactured by the plants which make the above products as well, although all of those plants, as shown by Table 11, do not make industrial finishes. In only two cases do the numbers of plants making industrial finishes outnumber those in the other categories -- in Mississippi and New Hampshire.

There is no discernible correlation between the percentage of plants making industrial finishes in conjunction with other products and the degree of the State's industrialization. While a great many of them are engaged in this production in industrial states such as Illinois, Michigan, New Jersey, etc., the same is true in many states not noted for industrial activities.

Distribution of Production

Table 12 illustrates the state-by-state distribution of various products in terms of their annual production rates. Illinois produces the largest amount of paint and coatings at 384 kkl (102 million gal.) per year with California, which has the largest number of paint plants, following close behind with 383 kkl (101 million gal.) per year. Highly industrialized states such as New Jersey and Ohio annually manufacture 311 kkl (82 million gal.) and 290 kkl (77 million gal.), respectively. Other populated and industrialized states also produce relatively large amounts of coatings as compared to the smaller states which generally produce less than 3.8 kkl (1.0 million gal.) each per year. The smaller states include Maine, West Virginia, and Arizona.

Factory-applied coatings are manufactured in greater quantities than any other type of paint. About 1057 kkl (279 million gal.) were produced in 1972 with Illinois and California each accounting for 136 kkl (36 million gal.). Solvent-thinned trade sale paints were next in production volume at 799 kkl (211 million gallons) with water-thinned trade sale paints following closely behind at 751 kkl (198 million gallons). As was pointed out earlier, water-thinned paints are gradually taking over a larger part of the trade sale paint business.

TABLE 12

SIC 2851 PAINT AND ALLIED PRODUCTS
ESTIMATED ANNUAL PRODUCTION RATES IN 1972

STATES	EPA REGIONS	QUANTITY OF SHIPMENT FKL (Gal. x 10^6)	SIC 28511 & 28513 SOLVENT THINNED PAINTS FKL (Gal. x 10^6)	SIC 28512 & 28514 WATER THINNED PAINTS FKL (Gal. x 10^6)	SIC 28515 & 28517 LACQUERS FKL (Gal. x 10^6)	SIC 28516 FACTORY APPLIED FINISHES FKL (Gal. x 10^6)
1 AL, MS	IV	18.93 (5.00)	5.07 (1.34)	4.77 (1.26)	2.35 (0.62)	6.74 (1.78)
2 AK, OR	X	13.59 (3.57)	3.63 (0.96)	3.40 (0.90)	1.67 (0.44)	4.81 (1.27)
3 AZ	IX	3.59 (0.95)	0.98 (0.26)	0.91 (0.24)	0.45 (0.12)	1.29 (0.34)
4 AR, LA, OK	VI	24.56 (6.49)	6.59 (1.74)	6.21 (1.64)	3.03 (0.80)	8.74 (2.31)
5 CA	IX	382.93 (101.17)	102.91 (27.19)	96.63 (25.55)	47.27 (12.49)	135.99 (35.93)
6 CO	VIII	13.06 (3.45)	3.52 (0.93)	3.29 (0.87)	1.63 (0.43)	4.66 (1.23)
7 CT	I	7.84 (2.07)	2.12 (0.56)	1.97 (0.52)	0.98 (0.26)	2.76 (0.73)
8 DE,NC,WV	III & IV	8.59 (2.27)	2.31 (0.61)	2.16 (0.57)	1.06 (0.28)	3.07 (0.81)
9 DC	III	See Delaware (See Note)				
10 FL	IV	44.51 (11.76)	11.96 (3.16)	11.24 (2.97)	5.49 (1.45)	15.78 (4.17)
11 GA	IV	100.34 (26.51)	26.99 (7.13)	25.32 (6.69)	12.38 (3.27)	35.65 (9.42)
12 HI	IX	No Paint Plants				
13 ID, MT, NV, NM,UT	X,VIII,& IX VI, VIII	9.99 (2.64)	2.69 (0.71)	2.54 (0.67)	1.25 (0.33)	3.56 (0.94)
14 IL	V	384.25 (101.52)	103.29 (27.29)	97.00 (25.63)	47.46 (12.54)	136.49 (36.06)
15 IN	V	47.50 (12.55)	12.76 (3.37)	11.99 (3.17)	5.87 (1.55)	16.88 (4.46)
16 IA	VII	40.46 (10.69)	10.86 (2.87)	10.23 (2.70)	4.50 (1.32)	14.39 (3.80)
17 KS, NB	VII	7.57 (2.00)	2.04 (0.54)	1.93 (0.51)	0.95 (0.25)	2.69 (0.71)
18 KY	IV	133.19 (35.19)	35.81 (9.46)	33.65 (8.89)	16.46 (4.35)	47.31 (12.50)
19 LA	VI	See Arkansas (See Note)				
20 ME,NH,VT	I	4.13 (1.09)	0.76 (0.20)	1.06 (0.28)	0.49 (0.13)	1.48 (0.39)
21 MD	III	61.09 (16.14)	16.43 (4.34)	15.44 (4.08)	7.53 (1.99)	21.69 (5.73)
22 MA	I	52.65 (13.91)	14.16 (3.74)	13.29 (3.51)	6.51 (1.72)	18.70 (4.94)
23 MI	V	184.56 (48.77)	49.62 (13.11)	46.59 (12.31)	22.79 (6.02)	65.56 (17.32)
24 MN	V	30.17 (7.97)	8.10 (2.14)	7.61 (2.01)	3.71 (0.98)	10.71 (2.83)
25 MS	IV	See Alabama (See Note)				
26 MO	VII	125.59 (33.18)	33.76 (8.92)	31.71 (8.38)	15.52 (4.10)	44.63 (11.79)
27 MT	VIII	See Idaho (See Note)				
28 NB	VII	See Kansas (See Note)				
29 NV	IX	See Idaho (See Note)				
30 NH	I	See Maine (See Note)				

NOTE: WITHHELD (BY CENSUS) TO AVOID DISCLOSING FIGURE FOR INDIVIDUAL COMPANIES.

Table 12 Cont'd.

SIC 2851 PAINT AND ALLIED PRODUCTS
ESTIMATED ANNUAL PRODUCTION RATES IN 1972

STATES	EPA REGIONS	QUANTITY OF SHIPMENT KKL (Gal. x 10^6)	SIC 28511 & 28513 SOLVENT THINNED PAINTS KKL (Gal. x 10^6)	SIC 28512 & 28514 WATER THINNED PAINTS KKL (Gal. x 10^6)	SIC 28515 & 28517 LACQUERS KKL (Gal. x 10^6)	SIC 28516 FACTORY APPLIED FINISHES KKL (Gal. x 10^6)
31 NJ	II	311.47 (82.29)	83.72 (22.12)	78.65 (20.78)	38.46 (10.16)	110.64 (29.23)
32 NM	VI	See Idaho (See Note)				
33 NY	II	161.81 (42.75)	43.49 (11.49)	40.84 (10.79)	19.98 (5.28)	57.46 (15.18)
34 NC	IV	53.97 (14.26)	14.50 (3.83)	13.63 (3.60)	6.66 (1.76)	19.19 (5.07)
35 ND	VIII	No Paint Plants				
36 OH	V	239.63 (76.52)	77.86 (20.57)	73.13 (19.32)	35.77 (9.45)	102.88 (27.18)
37 OK	VI	See Arkansas (See Note)				
38 OR	X	See Alaska (See Note)				
39 PA	III	181.68 (48.00)	46.83 (12.90)	45.87 (12.12)	22.45 (5.93)	64.33 (17.05)
40 RI	I	5.60 (1.48)	1.48 (0.39)	1.40 (0.37)	0.66 (0.18)	2.00 (0.53)
41 SC	IV	See Delaware (See Note)				
42 SD	VIII	No Paint Plants				
43 TN	IV	20.33 (5.37)	5.45 (1.44)	5.15 (1.36)	2.50 (0.66)	7.22 (1.91)
44 TX	VI	167.49 (44.25)	45.00 (11.89)	42.27 (11.17)	20.67 (5.46)	59.50 (15.72)
45 UT	VIII	See Idaho (See Note)				
46 VT	I	See Maine (See Note)				
47 VA	III	23.35 (6.17)	6.28 (1.66)	5.90 (1.56)	2.88 (0.76)	8.29 (2.19)
48 WA	X	21.65 (5.72)	5.83 (1.54)	5.45 (1.44)	2.69 (0.71)	7.68 (2.03)
49 WV	III	See Delaware (See Note)				
50 WI	V	39.44 (10.42)	10.60 (2.80)	9.95 (2.63)	4.88 (1.29)	14.00 (3.70)
51 WY	VIII	No Paint Plants				
NATIONAL		2975.34 (786.09)	799.40 (211.20)	751.28 (198.49)	367.36 (97.08)	983.19 (259.77)
EPA REGIONS	I	70.22 (18.55)	18.52 (4.89)	17.72 (4.68)	8.66 (2.29)	24.94 (6.59)
	II	473.24 (124.04)	127.21 (33.61)	119.49 (31.57)	58.44 (15.44)	168.10 (44.41)
	III	247.97 (65.48)	70.77 (18.70)	66.64 (17.59	35.67 (9.42)	74.89 (19.77)
	IV	385.17 (101.83)	106.92 (28.23)	100.12 (26.50)	48 [illegible]5 (12.63)	129.88 (34.47)
	V	975.58 (257.75)	262.23 (69.28)	246.27 (65.07)	120.48 (31.83)	346.52 (91.55)
	VI	170.28 (44.99)	50.01 (13.20)	47.08 (12.43)	22.46 (5.93)	50.73 (13.39)
	VII	173.20 (45.87)	46.66 (12.33)	43.87 (11.59)	20.97 (5.67)	61.70 (16.30)
	VIII	15.86 (4.20)	4.62 (1.22)	4.34 (1.15)	2.07 (0.55)	4.83 (1.28)
	IX	355.90 (94.03)	102.47 (27.10)	96.34 (25.43)	45.96 (12.13)	111.13 (29.34)
	X	34.36 (9.07)	9.99 (2.64)	9.41 (2.48)	4.49 (1.19)	10.47 (2.76)

NOTE: WITHHELD (BY CENSUS) TO AVOID DISCLOSING FIGURE FOR INDIVIDUAL COMPANIES.

Approximately 367 kkl (97 million gal.) of industrial and non-industrial lacquers were made in 1972. The quantities of putty and miscellaneous products manufactured were not readily available from census data or other reliable sources.

PAINT AND COATINGS MANUFACTURING WASTES CHARACTERIZATION

Introduction

This section characterizes the wastes of the paint and coatings industry destined for land disposal in terms of: sources, constituents, quantities, and potentially hazardous nature. The criteria for determining the hazardous or non-hazardous nature of a waste stream are set forth and the rationale for selecting this approach over other alternative criteria is presented.

The term "waste stream" is used to designate a source of waste generated within a paint plant. There are, however, no "waste streams" in paint plants in the usual sense of a continuous process stream. This is essentially a mixing industry, the processes of which do not in themselves create wastes. The wastes derive from raw materials packaging, finished products which must be discarded, air and water pollution control residues, and solvents used to clean equipment. Because of this, use of the term "process waste" is avoided in this report since it is misleading nomenclature in this industry.

The major components which in some combination form various types of paints and coatings -- pigments, binders, and solvents -- are discussed along with the additives used to impart special properties. The term "solvents" embraces both organic solvents and water, the latter providing the solvent or diluent for many modern paints.

There are thousands of raw materials which can interchangeably serve the functions of these basic components. Legal restraints on the use of lead and mercury compounds are also set forth.

The manufacturing processes employed by the industry are detailed and process flow diagrams are introduced. The current quantities of waste generated, which in this industry are more closely related to product manufactured than to the process used, are calculated from plant survey data on three bases:

1. Total waste
2. Total potentially hazardous waste
3. Total amount of hazardous constituents

These are extrapolated to state, EPA region, and national totals.

Future production trends and raw material changes in the industry are taken into account in projecting waste totals for 1977 and 1983.

Tables give quantities of total wastes since there is presently no segregation of hazardous and non-hazardous waste in this industry.

Criteria for the Determination of a Potentially Hazardous Waste

There are many definitions of "hazardous materials" in use today. They are variously designed for application in implementing the Clean Air Act, the Longshoremen's and Harbor Worker's Compensation Act, and Department of Transportation regulations. Others are built into pending legislation on solid waste disposal and still others have been adopted for purposes of EPA studies similar to this one but relating to other industries (35). The two considerations, stated or implied, most common to all of them are the potential for acute or chronic adverse effects. This concept is also inherent in the hazardous criteria applied throughout this report.

Five basic categories of hazardous characteristics of materials were established by EPA's Report to Congress, Disposal of Hazardous Waste (16). submitted in accordance with the Solid Waste Disposal Act. They are: toxic chemical, flammable, radioactive, explosive, and biological. The characteristics of materials used in the paint industry which may be classified as hazardous fall, so far as is known, within the first two categories. There are no radioactive or explosive raw materials used in the manufacture of paint and any biological activity in discarded paint wastes amounts to a simple fermentation process.

It was concluded, therefore, that the measure of toxicity and flammability provided the most direct means of defining substances as hazardous or non-hazardous insofar as this industry is concerned. As more data are developed on other complex effects -- bioconcentration, reactivity, and genetic change, for example -- which might occur as a result of the improper disposal of paint manufacturing wastes, these definitions may require revision.

Toxicity

The first criterion applied to a paint raw material in determining its hazardous nature was the measure of its toxicity. The following toxic effects which may occur in an acute and/or chronic form and jeopardize the health and welfare of humans and the safety and propagation of terrestrial or aquatic life forms were considered:

Oral toxicity
Inhalation toxicity
Dermal penetration toxicity
Dermal irritation reaction
Aquatic toxicity
Phytotoxicity

For purposes of this study, oral toxicity was accepted as the basis for defining a toxic substance because there are generally much more data available to support published conclusions based on this parameter.

A major toxicological reference work, Clinical Toxicology of Commercial Products (1) was adopted for use in the criteria for determining the toxic, and thus potentially hazardous, nature of a material. This volume rates the toxicity of various compounds used in industry on a scale of 1 to 6. This numerical rating represents toxic levels from "practically non-toxic" to "super toxic" and is shown in Table 13. The implications and limitations which should be taken into account in using the table are outlined in Appendix C.

This volume (authored by Gleason, Gosselin, Hodge, and Smith) is generally accepted and is the most comprehenisve publication found. However, in selecting its rating system for use in this study, certain deficiencies, in this particular application, were recognized. It does not in all cases agree with the findings of other equally reputable researchers; and, in a few instances, a relevant compound is assigned different ratings in different portions of the book. The difference is between the estimate of toxicity of a product as it is marketed and the inherent toxicity of a single ingredient. The former is considered the more realistic in terms of clinical exposure and where conflicts occur is the one presented here.

Such deficiencies are not confined to this volume alone and in general are true of the body of toxicological literature which was searched. It is replete with descriptions and documentation of the toxicity of the elemental parent substances. But reliable information on certain specific compounds used by the paint industry is sparse or apparently non-existent on some compounds which have only recently come into use, and multiple references are frequently in conflict with one another.

The most serious deficiency of the literature for purposes of this project is that it is nearly all occupationally or laboratory oriented. The result is that toxic effects documented are responses to higher concentrations than levels which could be expected to accrue from deposition of relatively small quantities of these substances in a landfill. Few epidemiological facts are available and within the scope of this project, information developed on the basis of occupational or laboratory exposure must be substituted.

It was decided that Clinical Toxicology of Commercial Products (1) offered a source of data which is essentially a compilation of data developed from a much broader selection of material than could be researched and evaluated within the project schedule. Its widespread acceptance also supported the adoption of its toxicity ratings as the yardstick of toxicity in determining the hazardous nature of individual materials.

TABLE 13

DEFINITION OF TOXICITY RATING (1)

	TOXICITY RATING OR CLASS	PROBABLE LETHAL DOSE (HUMAN) mg/kg	PROBABLE LETHAL DOSE (HUMAN) for 70-kg man (150-lb)
Potentially Hazardous	6 - super toxic	less than 5	a taste (less than 7 drops)
	5 - extremely toxic	5 - 50	between 7 drops & 1 tsp.
	4 - very toxic	50 - 500	between 1 tsp & 1 oz.
	3 - moderately toxic	500 - 5 gm/kg	between 1 oz & 1 pt (or 1 lb.)
	2 - slightly toxic	5 - 15 gm/kg	between 1 pt & 1 qt
	1 - practically non-toxic	above 15 gm/kg	more than 1 qt

A rating of 3 on this scale is "moderately toxic." This rating means, according to Gleason, et al., that a dose of between 0.03 liters (1 oz) and 0.5 liters (1 pt) or 0.5 kg (1 lb) of a substance with this rating would probably be lethal to a 70-kg (150-lb) man; one-tenth of this dose might be expected to result in a "clinically significant illness." In this report, any material with a toxicity rating of 3 or above is defined as potentially hazardous.

This is a conservative approach and is based more on unknown factors than known ones. It may result in the classification of some compounds as toxic which, because of their own individual physical or chemical characteristics -- insolubility, particle size, or degree of purity -- may or may not share the extreme toxicity of their parent elements. In addition, ascribing certain toxic effects to substances encapsulated in resins or resinous materials is not necessarily an accurate gauge of their toxic effects in a landfill. However, in view of the unknowns of their behavior under all environmental conditions including synergism or inhibition, the narrower criterion of a 4 or above rating seems unwise.

In the absence of a rating by Gleason, et al., data were sought from other literature sources on the materials used by surveyed plants which contain one or more of the substances listed on Page 99 and those found were used where necessary. Such compounds on which no expert consensus of non-toxicity was found in Gleason or elsewhere are considered to be at least moderately toxic and thus potentially hazardous for purposes of this study.

The rating of 3 embraces numerous materials whose toxic effects may be reduced somewhat by exposure in the open air, especially solvents. These flammable materials are volatile and can evaporate to a large extent if they are spread over the ground. However, part of the solvents can seep into the ground, posing a potential hazard due to flammability or contamination of groundwater supplies.

Wastes containing only constituents with ratings of 2 or 1 are considered non-hazardous from a toxicity standpoint. It was concluded that a base line rating of 2 or 1 is without justification, from either a margin of safety or an economic point of view. Circumstances in which one subject would ingest or otherwise receive sufficient quantities of substances in these classes from the land, ambient air, or water to generate toxic effects are not envisioned.

Flammability

The second criterion applied to the raw materials of paint in determining their hazardous nature was the measure of flammability. Any substance with a flash point of 27°C (80°F) or less as measured by the Tag Open Tester is deemed potentially hazardous. This is the limit which has been used by the Department of Transportation to designate the hazardous flammable solvents which require a red label warning. (Since the data for this study were gathered, this limit has been raised to 38°C (100°F).

The application of the measure of flammability to organic solvents is quite precise. This information is widely available in chemical and supplier literature. The flash point of mixed solvents is not as well established although a new test procedure has been developed (17). For purposes of this study, however, any mixture of organic solvents containing material with a flash point of 27°C (80°F) or below is considered potentially hazardous.

It will be noted that in subsequent discussions and tables on quantities of potentially hazardous wastes, they are divided into toxic chemical and hazardous solvent categories. This is done to identify separately the quantities of flammable substances to be dealt with in disposal, although they may also fall within the toxic characterization as well. This is explained more fully in ensuing pages.

Definition of Potentially Hazardous Waste Streams

A waste stream generated within a paint plant is, for purposes of this study, defined as a potentially hazardous waste if it contains or may contain, according to production, one or more materials defined as toxic and/or flammable according to the above criteria. This broad definition lacks precision. However, it was the alternative chosen over others which appeared less environmentally adequate. For example, if a criterion were applied based on the percentage level of toxic or flammable constituents, materials could theoretically be rendered non-hazardous by dilution since the concentration of hazardous constituents may vary over a wide range in common practice. Such a concept is not acceptable, however, as dilute constituents may be concentrated during handling or incineration or after disposal in a landfill. A human experience criterion was likewise discarded because while there may be no recorded evidence of morbidity or mortality effects resulting from the constituents of a given waste stream, neither is there any documented evidence to the contrary. Within the scope of this project, the contractor is not prepared to estimate the alternative probabilities.

Any attempt to use either of these two criteria or a combination of both would be seriously hampered by several additional factors. A major one is the scarcity of correlation in the literature between concentrations of materials and morbidity and mortality data. Most frequently an episode -- ranging from simple irritation to death -- is described without reference to the amount of the compound which engendered it. In the few cases where this information is given on paint raw materials, the concentrations are in almost all instances those attendant to the manufacture of the raw material or to other long time, intimate exposure to high indoor industrial atmospheric concentrations of several hundred to several thousand parts per million, levels which will not be reached in the ambient air as a result of disposing of small quantities of wastes on land. In addition, as discussed previously in connection with toxicological information, relevant morbidity and mortality references are often in conflict and they offer little in the way of substantiation (38, 39, 40, 41, 42, 43, 44, 45, 46, 47).

Another inhibiting factor in the use of constituent percentage or human health criteria for defining a waste stream as potentially hazardous or non-hazardous is that while some of the compounds used in paint might be considered non-hazardous in the form employed, the possibility exists that they will be changed into other, highly toxic compounds in the disposal environment. In view of all the foregoing circumstances, the broader definition is preferred.

It should be noted that this definition embraces coatings which account for a large percentage of the industry's production, yet which are only assigned a toxicity rating of 2 as finished products (1). These include latex interior and exterior paints and some lacquers and anti-corrosion paints. This is dictated, however, by the potential presence of mercury as an additive in these products, and the fact that they are seldom segregated from other waste streams in disposal.

Manufacturing Processes

The production of all types of coatings is accomplished by mixing, a process which can be achieved in several ways, any of which is relatively simple compared to the complexity of many other industrial technologies. While some paint manufacturers produce their own resins or other raw materials, this study is concerned only with the potentially hazardous waste generated by the production of paint itself as defined by SIC 285. Thus, this process description assumes that the final product is made entirely of purchased raw materials. However, the data generated by the plant surveys no doubt include, in some cases, wastes from resin manufacture since they are not always segregated.

The type of equipment used in paint production depends upon the ease with which mixing can be achieved. This process includes the breaking up of aggregates of solid particles (18) and the wetting of solid surfaces by the liquids. Grinding may also be employed depending on the form in which the pigment is received. It is necessary to reduce the particle size of some pigments by grinding and others can be incorporated into the binder or vehicle without grinding. Most pigments today fall into the latter category. The need for grinding has also been diminished by the development of more effective wetting agents.

The equipment used is also governed by the product formulation. Many formulations can be processed on more than one type of equipment although for some formulations one type mill is distinctly superior to another in effecting dispersion.

The amount of mixing needed to produce a suitable dispersion of pigmented materials depends upon the ingredients. Some pigments, such as red lead and aluminum powder, will disperse in certain liquids with only enough stirring to assure a uniform distribution. At the other extreme, some carbon blacks are so difficult to disperse and wet properly that few paint plants undertake the job, preferring to purchase pre-dispersed materials from companies specializing in that work.

The various mixing machines used include roller mills, ball or pebble mills, sand mills, a few high-speed stone mills, and a variety of simple mixers such as stirrers and Banbury mixers. Each of these has its own characteristics, which determine, in specific cases, which ones are used.

If dispersion alone is required a roller mill may be utilized. The three-roll mill, consisting of three rotating cylindrical drums, is most common, and requires premixing of the materials to be dispersed (18).

Pebble and ball mills are capable of both mixing and grinding. Their use is dwindling with reduced grinding requirements. Dispersion in these devices is achieved by the tumbling action of steel balls in the latter and non-metallic media, such as natural flint pebbles or porcelain balls, in pebble mills.

The newest dispersion equipment is the sand mill, a perpendicular, cylindrical shell containing sand or small porcelain balls as its grinding media. While this process is a continuous operation, it, too, requires premixing and a batch tank for this purpose is integral to the process (18).

High-speed disc impellers, which resemble milk shake mixers or home-type blenders, are used to some extent for pigments in which the particles are easily separated and which can be dispersed in coarser form. These devices are employed primarily for interior and exterior wall paints. Certain products such as putty are mixed in machines similar to commercial dough mixers, or in such mixers themselves.

When tinting or thinning is required, these steps immediately precede the packaging step. Tinting pigments are almost always predispersed, and a high-speed disc impeller or other mechanical stirring device is usually employed.

In the manufacture of clear finishes with no pigment, the dispersion step is not needed. Only enough stirring to assure a uniform mix of resin solution (or varnish), thinners, and additives is required.

The various types of equipment have other characteristic differences. These include the amount of supervision needed -- pebble mills, for example, are often allowed to operate over-night unattended -- the rate of through-put, the fineness of pigment dispersion achieved, the temperature reached during the operation (some pigments and vehicles are heat-sensitive), and other factors. The choice of the proper machine to achieve desired results is one of the major functions of a plant manager.

At the end of the process the paint is packaged in cans -- from 0.1 liter (1/4 pint) up to 7.6 liters (2 gal.) -- pails of 18.9 and 27.8 liters (5 and 10 gal.), or steel drums of up to 208 liters (55 gal.). A few large scale manufacturers deliver some products to large customers in 11,000-liter (3000-gal.) tank trucks. In the smaller plants, all filling is done by hand, but in most plants cans are filled automatically. Pails, drums, and tank trucks are almost always filled manually.

(A Task Force of the NPCA and a Committee of the Federation of Societies for Coating Technology (FSCT) are discussing container sizes to be adopted in the future. These will undoubtedly be round numbers based on the liter, but several points remain to be resolved.)

There are many variations in the above practices, determined by the equipment available, customer requirements, and other factors. Some plants may manufacture some of their raw materials, and others will purchase partially finished products for finishing and repacking in their plants.

Formulations

A plant producing a relatively complete line of paints, including factory-applied coatings, may utilize between 1500 and 5000 different raw materials depending on the size of the manufacturing operations. This is explained to a large degree by the fact that the formulation of any paint or coating is a compromise among the various properties that users want or require. Since these characteristics vary in compatibility some kind of "trade-off" is usually necessary.

A simple case can be illustrated by conventional flat wall paints. These should be washable, so that dirt and stains can be removed without difficulty or damage to the paint coat, and, at the same time, the paint should have the highest possible hiding power, so that any background can be covered in one coat. These two properties are essentially incompatible -- the higher the pigment content is, the better the hiding power will be, and the higher the vehicle content, the better the washability. Each paint formulator makes his paint with an eye to the balance of these two which he feels his customers prefer.

In addition, he must consider brushability, color, color retention, drying time, gloss, etc. Since each of these combinations may be achieved by different sets of raw materials, it is no wonder that different formulators utilize different raw materials to make essentially the same final product and thus lengthen the list of chemicals used.

Other constraints are placed on factory-applied coatings which will be used on established production lines. A proposed coating must be adapted to the application method used -- a spray gun or other device -- and must flow out, level, and dry within the time limit provided by the production line, in some cases only a few seconds. In addition, many commercial uses demand a specific color within a very close tolerance. After such specialized requirements are met, often with specific raw materials, the formulation is adjusted to achieve the best combination of other properties.

Some typical formulas are given in Table 14 to illustrate the way in which the formulations may be changed to achieve: 1) variations in gloss for an interior alkyd; 2) variations in floor finishes ranging from a clear varnish to an oak stain to a brown enamel; and 3) variations in a clear and pigmented lacquer in shades of blue. Composition is given in percent by weight of each ingredient. Certain minor ingredients such as anti-settling agents, fungicides, and levelling agents are omitted. The kind and amount of these used can vary widely depending upon specific end use of the product and they do not affect the principle illustrated. The amounts are always less than one percent.

Industry Subcategories

Solvent-thinned Trade Sales Paints

Manufacturing Processes

A typical flow diagram of the manufacture of solvent-thinned trade sales paints is shown in Figure 3. Possible variations in equipment used and the particular ingredients are determined by the specific product being manufactured, the available equipment, and other factors. Roller mills and sand mills are used for pigment dispersion while pebble or ball mills are used for mixing and grinding. The use of high speed disc impellers in conventional mixing tanks is also popular.

Typical Formulation

A typical formulation for a white gloss interior enamel is given in Figure 4. Light colors, or tints, are produced by adding color pigment to the titanium dioxide. As an alternative, many manufacturers make the white base and supply dispersed tinting colors so that the

TABLE 14

TYPICAL FORMULATION CHANGES TO ACHIEVE A VARIETY OF COATINGS (PERCENTAGE BY WEIGHT)

Typical Alkyd Finishes	High Gloss	Semi-gloss	Flat
Titanium dioxide	30.0	25.0	20.0
Extenders	--	10.0	25.0
Alkyd solids	40.0	30.0	19.0
Solvents	28.0	33.5	35.0
Driers	2.0	1.5	1.0
	100.0	100.0	100.0

Typical Floor Finishes	Clear	Oak Stain	Brown Enamel
Yellow iron oxide		5.0	
Brown iron oxide			20.0
Extenders		5.0	
Resin solids	50.0	28.0	40.0
Solvents	47.5	60.0	38.0
Driers	2.5	2.0	2.0
	100.0	100.0	100.0

Typical Lacquers	Clear	Dk. Blue	Lt. Blue	White
Titanium dioxide		3.0	10.0	12.5
Blue pigment		2.0	1.0	
Nitrocellulose	12.5	10.0	10.0	10.0
Resin/plasticizer	12.5	10.0	10.0	10.0
Solvents	75.0	75.0	69.0	67.5
	100.0	100.0	100.0	100.0

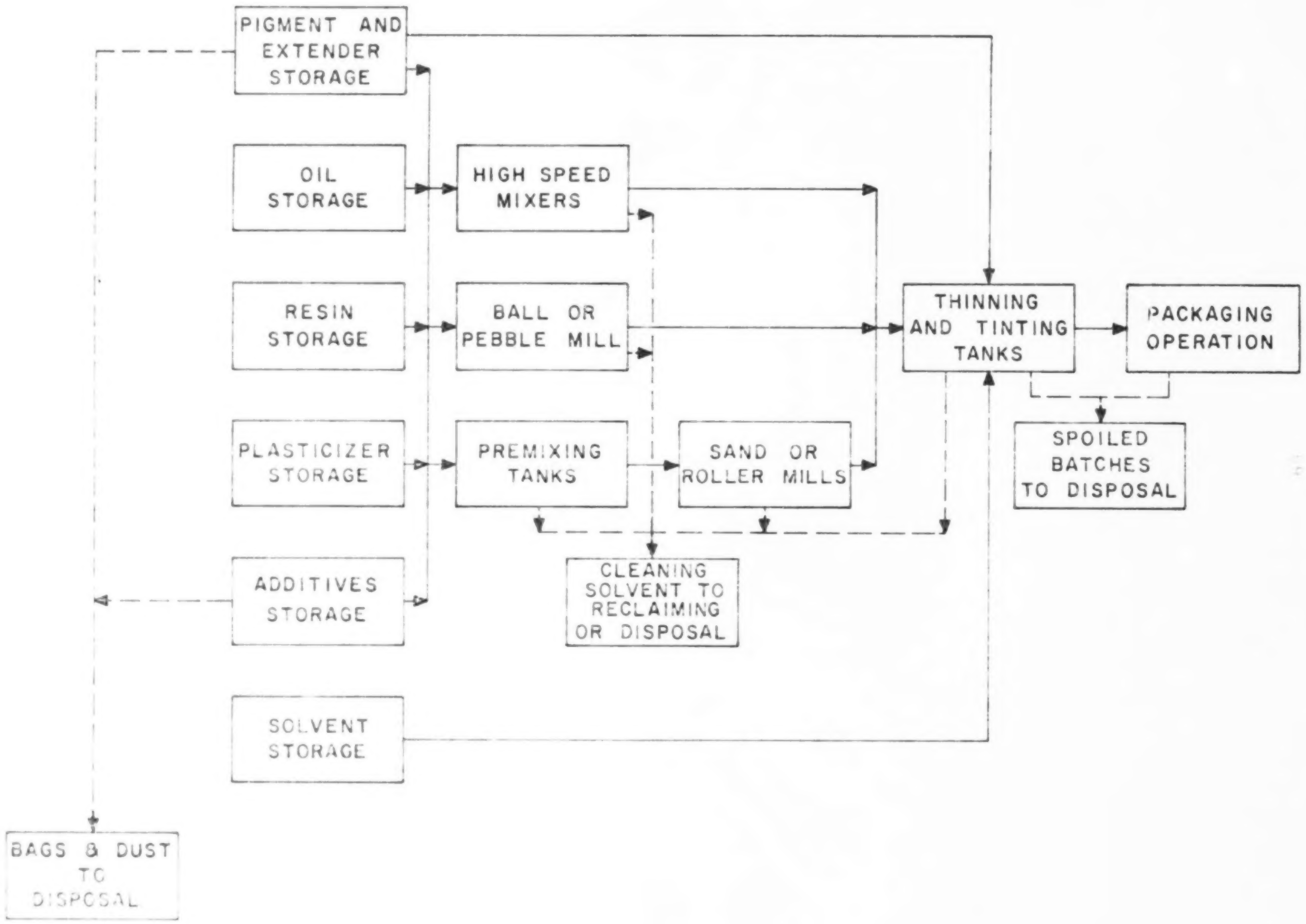

PIGMENT AND EXTENDER STORAGE
OIL STORAGE
RESIN STORAGE
PLASTICIZER STORAGE
ADDITIVES STORAGE
SOLVENT STORAGE
HIGH SPEED MIXERS
BALL OR PEBBLE MILL
PREMIXING TANKS
SAND OR ROLLER MILLS
CLEANING SOLVENT TO RECLAIMING OR DISPOSAL
THINNING AND TINTING TANKS
PACKAGING OPERATION
SPOILED BATCHES TO DISPOSAL
BAGS & DUST TO DISPOSAL

FIGURE 3

SOLVENT-THINNED PAINT MANUFACTURING FLOW DIAGRAM

FIGURE 4

TYPICAL SOLVENT-THINNED PAINT FORMULATION

MATERIAL	COMPOSITION	
	WEIGHT PERCENT	VOLUME PERCENT
PIGMENT:		
TITANIUM DIOXIDE	29	9
SOLVENT:		
MINERAL SPIRITS	15	22
RESIN:		
LONG OIL, TALL OIL ALKYD (70% NVM)	52	65
ADDITIVES:		
SUSPENSION AND FLOW AGENT	<1	1
6% COBALT NAPHTHENATE	<1	<1
4% CALCIUM NAPHTHENATE	<1	1
6% ZIRCONIUM DRIER CATALYST	1	2
ANTISKINNING AGENT	<1	<1
	100	100

retailer can add pigment at the point of sale to make the color the customer desires and avoid large inventories. Darker colors involve the substitution of the appropriate color pigment for some or all of the titanium dioxide. Semi-gloss and flat paints are obtained by increasing the ratio of pigment to vehicle. Since more hiding power is not normally required, the pigment is usually supplemented with transparent extender pigments (talc, calcium carbonate, etc.)

Other resins may be substituted for alkyds to achieve specific desired properties. Epoxy resins contribute adhesion and chemical resistance and are often used in floor and deck enamels, for example. Urethane resins contribute abrasion resistance and are frequently used in coatings where a high degree of washability is required. Acrylic resins have excellent color retention, and, in particular, resist yellowing. Each of these resins represents a group of materials with a range of properties so these descriptions are only generalities. Any paint ingredient has drawbacks, as well as advantages, and part of the art of formulation is to blend various ingredients to achieve the largest number of benefits and the smallest number of disadvantages.

Exterior paints usually contain either a straight drying oil (linseed, soybean, or safflower) or a different alkyd resin from that used in interior paints (generally a higher oil content).

In addition to the above there are many other solvent-thinned trade sales products which do not fit into the "typical formula" even with modifications. These include clear coatings and stains, and the formulations for which are illustrated in Table 14. Others are marine paints, traffic paints, metallic paints, and numerous special products.

Water-thinned Trade Sales Paints

Manufacturing Processes

A typical flow diagram of the manufacture of water-thinned trade sales paints is shown in Figure 5. The factors governing the selection of equipment are much the same as those for solvent-thinned trade sales paints. The principal difference between the two operations is that in water-thinned paints often all, or most, of the resin (latex) is withheld from the mechanical dispersion operation, since many latexes will be destabilized by this process. In general, the pigment is dispersed in water along with additives such as emulsifiers which will help to wet the pigment. The bulk of the latex, other additives, and additional water, if required, will then be added in the thinning tank. If predispersed pigments are used, as is the case where pigments are purchased in bulk as a slurry, the entire dispersion operation is dispensed with, and all the mixing is done in the thinning tank.

Some water-thinned paints are made by making a more-or-less conventional solvent-thinned paint with less than the usual amount of

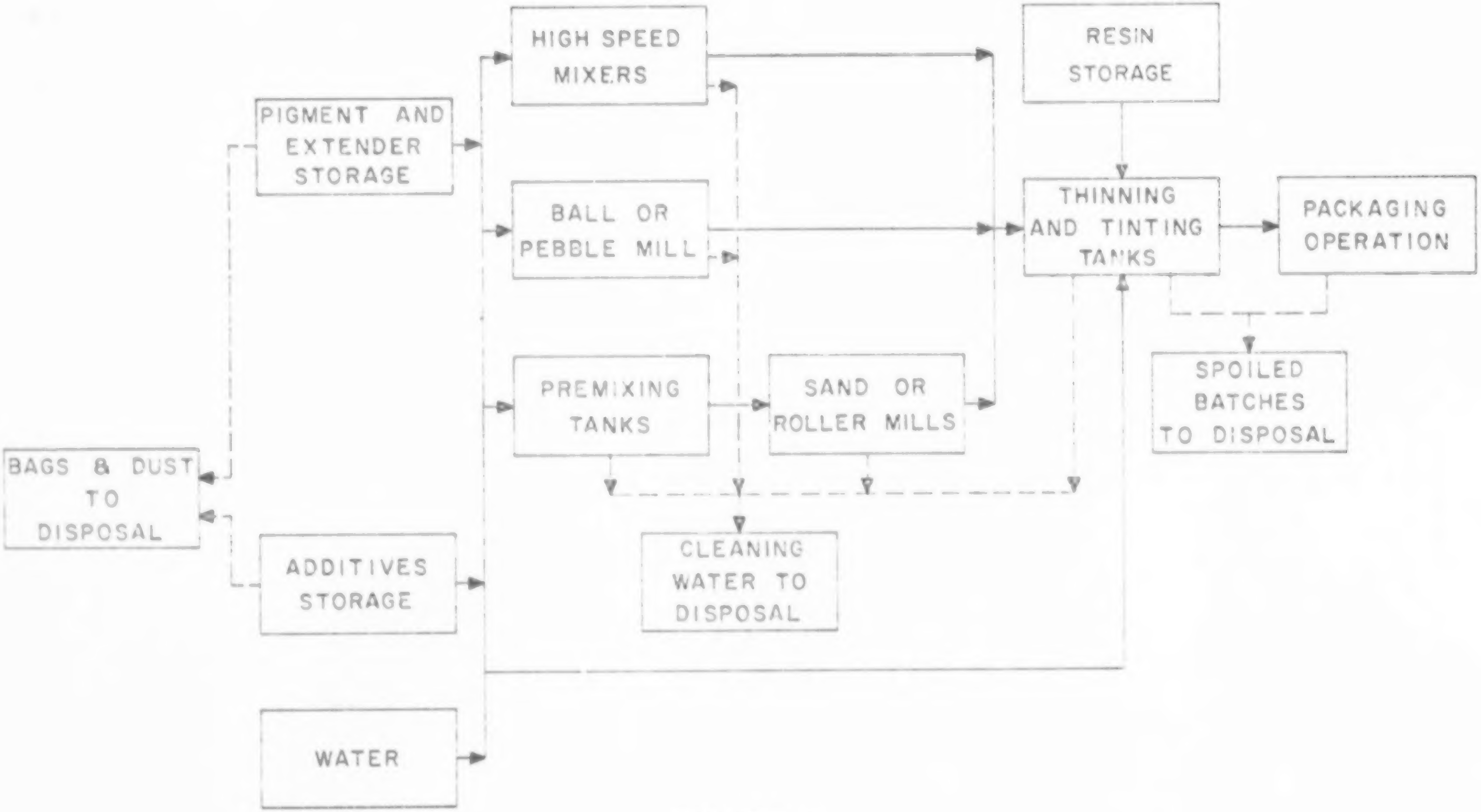

HIGH SPEED MIXERS
RESIN STORAGE
PIGMENT AND EXTENDER STORAGE
BALL OR PEBBLE MILL
THINNING AND TINTING TANKS
PACKAGING OPERATION
PREMIXING TANKS
SAND OR ROLLER MILLS
SPOILED BATCHES TO DISPOSAL
BAGS & DUST TO DISPOSAL
ADDITIVES STORAGE
CLEANING WATER TO DISPOSAL
WATER

FIGURE 5

WATER-THINNED PAINT MANUFACTURING FLOW DIAGRAM solvent and emulsifying with water after manufacture. This is not common today. In another variation of water-thinned paints, linseed oil or varnish vehicle is utilized which contains little or no water. This is treated, however, so that it is water emulsifiable and the paint can be thinned with water, and brushes and other tools can be cleaned with water. This type of formulation has not had wide-spread use.

Typical Formulation

Figure 6 shows a typical water-thinned interior formulation. As has been discussed previously, the choice of the kind and amount of pigment and extender is determined by the color, gloss, and other properties desired. The latex used may be polyvinyl acetate, as in the example, or, alternatively, an acrylic or butadiene-styrene emulsion. Increasingly, there is a tendency to use copolymers or terpolymers of several different monomers, in the hope of incorporating the virtues of several materials into one product.

In the case of trade sales products, solvents are rarely incorporated as such, but appear as significant parts of the various additives. Antifreezes are essentially organic solvents, as are many antifoams. Dispersants, fungicides, and thickeners are often dispersed in organic solvents as purchased. Exterior latex paints are usually made from acrylic or polyvinyl acetate latexes and usually with a different grade of titanium dioxide to control chalking. Most latex paints dry to a flat finish, but recently semi-gloss latexes have been developed. These usually have less pigment and less extender. Additives to improve flow and levelling are usually also included.

Lacquers

Manufacturing Processes

Figure 7 shows a flow diagram for a typical plant manufacturing nitrocellulose lacquer. Some operators purchase pre-dispersed pigments, in which case the dispersion step can be eliminated. Clear lacquers, of course, do not contain pigments, and all the ingredients are fed into the batch mixing tank. Lacquers are usually expected to produce a thin, uniform coating and, therefore, all large particles, either of pigments or agglomerations of "seeds" from the vehicle, must be removed. A centrifuge may be used for clear lacquers or, alternatively, filtering may be employed to remove this suspended material. Centrifuging is rarely used for pigmented materials, since the pigments are usually heavier than the vehicle and will separate, regardless of size.

Typical Formulation

Figure 8 gives a typical formulation for a clear nitrocellulose lacquer. Opaque and colored lacquers are obtained by adding suitable pigments as shown in Table 14. Since opaque and colored lacquers are

FIGURE 6

TYPICAL WATER-THINNED PAINT FORMULATION

	COMPOSITION	
MATERIAL	WEIGHT PERCENT	VOLUME PERCENT
PIGMENT AND EXTENDER:		
TITANIUM DIOXIDE	21	7
CLAY	17	9
SOLVENT:		
WATER	20	28
RESIN:		
VINYL ACETATE	38	51
ADDITIVES:		
DISPERSANTS	2	3
ANTIFREEZE	1	2
THICKENER	< 1	< 1
FUNGICIDE	< 1	< 1
ANTIFOAM	< 1	< 1
	100	100

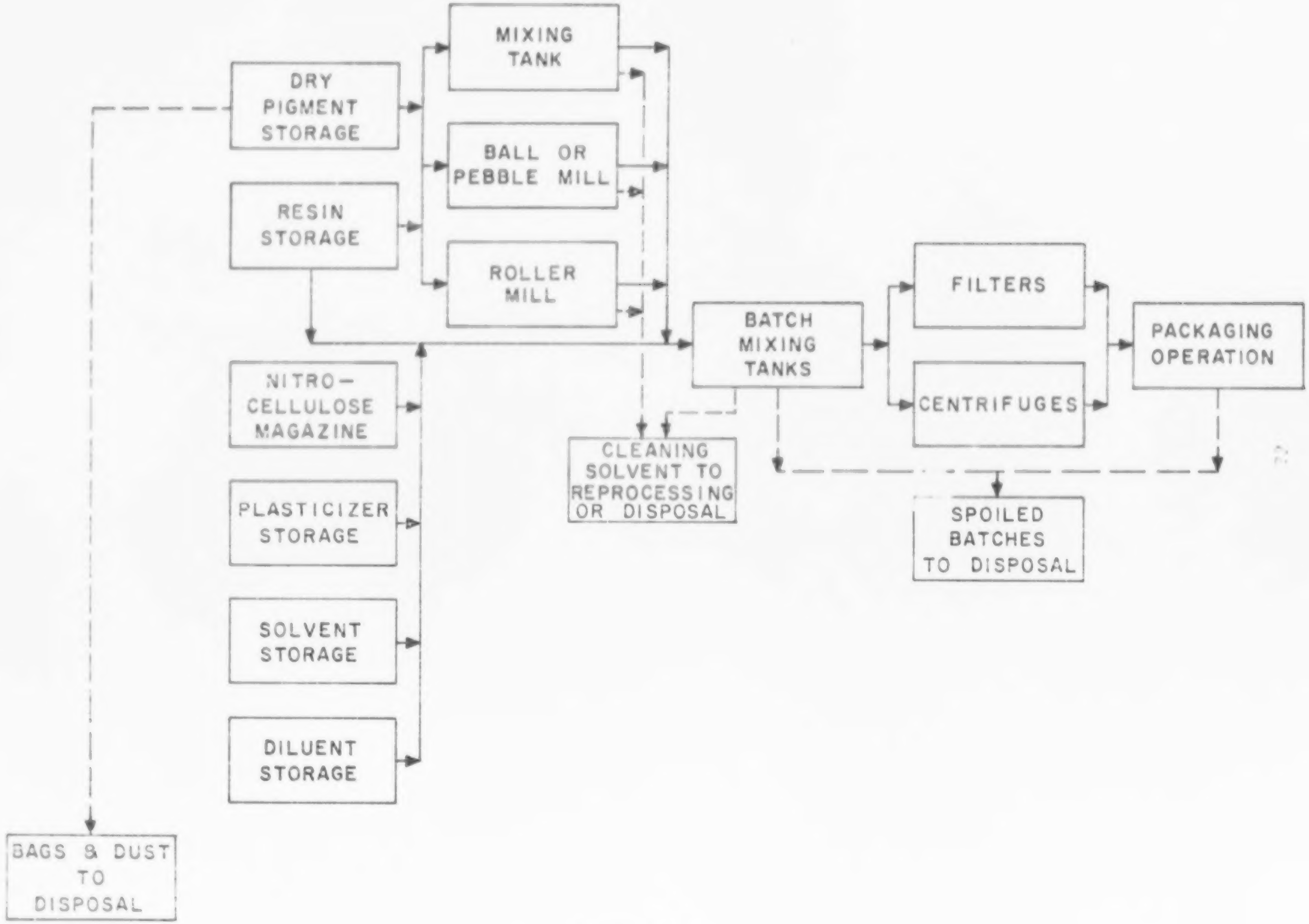

DRY PIGMENT STORAGE
RESIN STORAGE
NITRO-CELLULOSE MAGAZINE
PLASTICIZER STORAGE
SOLVENT STORAGE
DILUENT STORAGE
MIXING TANK
BALL OR PEBBLE MILL
ROLLER MILL
BATCH MIXING TANKS
FILTERS
CENTRIFUGES
PACKAGING OPERATION
CLEANING SOLVENT TO REPROCESSING OR DISPOSAL
SPOILED BATCHES TO DISPOSAL
BAGS & DUST TO DISPOSAL

FIGURE 7

LACQUER MANUFACTURING FLOW DIAGRAM

required to hide in a very thin film, extenders are rarely used, except in semi-transparent or translucent materials.

Lacquers, by definition, are coatings that dry solely by evaporation of the solvent. Nitrocellulose is the traditional resin used, but in recent years other resins such as solvent-thinned vinyl and acrylic resins have been used extensively. In both these resins, blends may be used to produce a wide range of hardness and flexibility. In effect, the plasticizer is incorporated in the resin and an additional plasticizer may not be needed. With resins other than nitrocellulose, the clear-cut distinction between "solvent" and "diluent" disappears. Blends of two or more solvents are often used to obtain the evaporation rate and other properties desired, but it is difficult to classify them separately as either solvents of diluents.

Certain other coatings, such as shellac varnish and some bituminous coatings, also dry entirely by solvent evaporation, but are rarely referred to as lacquers. They are, however, manufactured essentially according to the flow diagram given in Figure 7.

Factory-Applied Coatings

Manufacturing Process

There is almost no difference in the manufacturing process between most industrial paints and trade sales solvent-thinned paints. What difference there is tends to be quantitative rather than qualitative. For example, since industrial paints generally dry more rapidly, and, therefore, use lower boiling solvents, more of them are made in closed mills to reduce solvent loss. These include ball or pebble mills, or sand mills, as opposed to three-roll mills, high-speed mixers, and other open mills. A typical flow diagram of the manufacture of factory-applied coatings is shown in Figure 9.

Formulations

No typical formulation is given for industrial finishes, since over 5000 different formulas are used in conventional products, and it is doubtful that any one of them represents a significant portion of the total . In fact, many of these products are tailored to a particular assembly line on which they are to be used, and any change in that line may call for coating reformulation.

However, a few formulations are given in Figure 10 to show some general principles and the types of hazardous materials which may be used. Differences between these formulations and solvent-thinned trade sales products tend to be quantitative rather than qualitative. Lower boiling solvents are often used in factory-applied finishes, and therefore the fire hazard may be greater. Many industrial coatings are cured by baking, and require less drier. Therefore, the amount of

FIGURE 8
TYPICAL LACQUER FORMULATION

MATERIAL	COMPOSITION	
	WEIGHT PERCENT	VOLUME PERCENT
FILM FORMING MATERIAL:		
NITROCELLULOSE	22	10
ALKYD RESIN	5	6
PLASTICIZER:		
TRICRESYL PHOSPHATE	11	10
SOLVENTS:		
METHYL ETHYL KETONE	6	8
METHYL ISOBUTYL KETONE	6	8
BUTYL ALCOHOL	3	3
ISOPROPYL ALCOHOL	3	4
DILUENTS:		
TOLUENE	33	37
ACETONE	11	14
	100	100

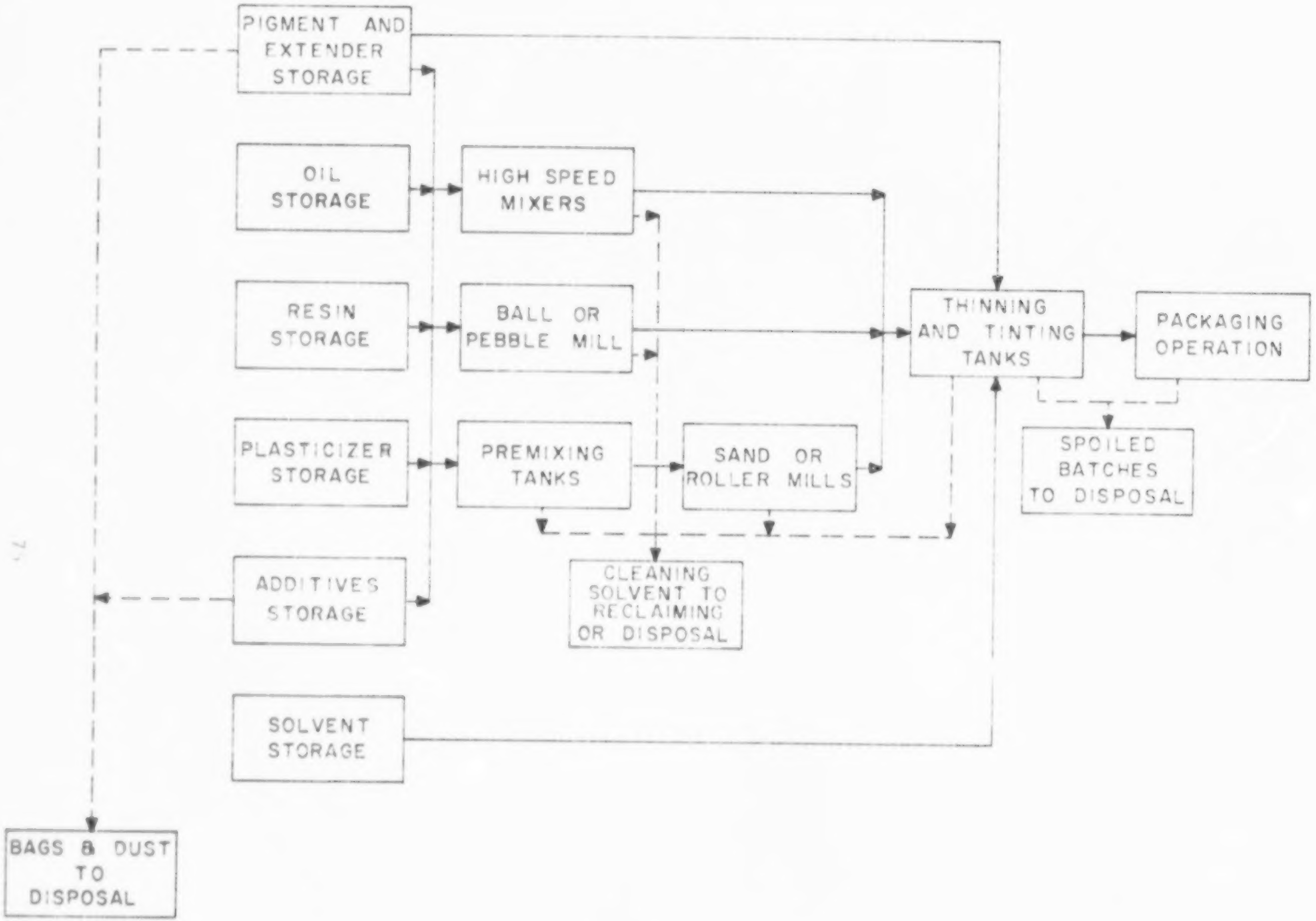

PIGMENT AND EXTENDER STORAGE
OIL STORAGE
RESIN STORAGE
PLASTICIZER STORAGE
ADDITIVES STORAGE
SOLVENT STORAGE
HIGH SPEED MIXERS
BALL OR PEBBLE MILL
PREMIXING TANKS
SAND OR ROLLER MILLS
CLEANING SOLVENT TO RECLAIMING OR DISPOSAL
THINNING AND TINTING TANKS
PACKAGING OPERATION
SPOILED BATCHES TO DISPOSAL
BAGS & DUST TO DISPOSAL

FIGURE 9

FACTORY-APPLIED COATING MANUFACTURING FLOW DIAGRAM

FIGURE 10

FACTORY-APPLIED COATINGS FORMULATIONS

	Weight Percent	Volume Percent
INDUSTRIAL BAKING ENAMEL:		
Titanium dioxide, Rutile	28	8
Alkyd resin, 50% solids	42	51
Urea resin, 50% solids	14	17
Xylene	16	24
	100	100
EPOXY CLEAR COATING:		
Tall oil, epoxy ester, 50% solids		72
Melamine resin solution, 50% solids		8
Catalyst, 10% solids		1
Xylene		13
Butanol		6
		100
FAST BAKING BROWN OXIDE PRIMER:		
Brown iron oxide	44	12
Modified phenolic varnish(1)	42	66
Urea resin, 60% solids	6	8
VM and P naphtha	6	12
6% manganese naphthenate	1	1
24% lead naphthenate	1	1
	100	100

Note: (1) Modified phenolic varnish composition:

Modified phenolic resin	100 lbs.
Tung oil	12.5 gal.
Bodied linseed oil	12.5 gal.
Mineral spirits	46 gal.

cobalt, lead, and manganese is likely to be lower in industrial coatings. Fewer lead pigments are also used in factory-applied coatings. Otherwise, the content of toxic metal compounds will be determined by the color required, and will be similar to that of trade sales products.

Powder Coatings

The large scale manufacture of powder coatings for industrial use is relatively new and many of the manufacturing details remain proprietary. Fundamentally, the process consists of the dispersion of suitable pigments in a thermo-plastic resin with a fairly high melting point. The resin must be liquefied for this purpose, which may be done by heating or by dissolving in a small amount of a strong solvent.

When heat is employed, the mixture is chilled after dispersion and reduced to suitable particle size by grinding. This heating-chilling process, shown in Figure 11, is a closed system which should produce no waste. The ground pigment is passed through a classifier from which over-size particles are returned to the grinder and under-size particles are heated again and returned to the mixer. Pigment bags and dust from additive storage are, in theory, the only process wastes generated.

The use of a solvent is probably a less common method of powder coatings manufacture. This procedure also utilizes a closed system and should in theory have no waste with all unused materials being returned to process according to the manufacturers.

Since a suitable resin is absolutely essential to a satisfactory product, powder coating manufacture is often carried out as an adjunct to resin manufacture, and any wastes that do occur, in fact, are usually combined with other wastes of the resin manufacturing operation and are outside the scope of this report.

Putty and Miscellaneous Paint Products

Manufacturing Process

Practically all putty is made by a process similar to the mixing of dough in a bakery or in the home. Either a heavy roller passes over the mixture, which is gathered together and folded over for the next pass, or else a slowly rotating mixing arm (or arms) mixes the pigment and binder. It is mixed only to the point of desired consistency. Figure 12 shows a flow diagram of a typical putty manufacturing operation, and probably describes more than 90 percent of them.

The general class of miscellaneous materials which are part of the total production of the paint industry is sufficiently diverse in

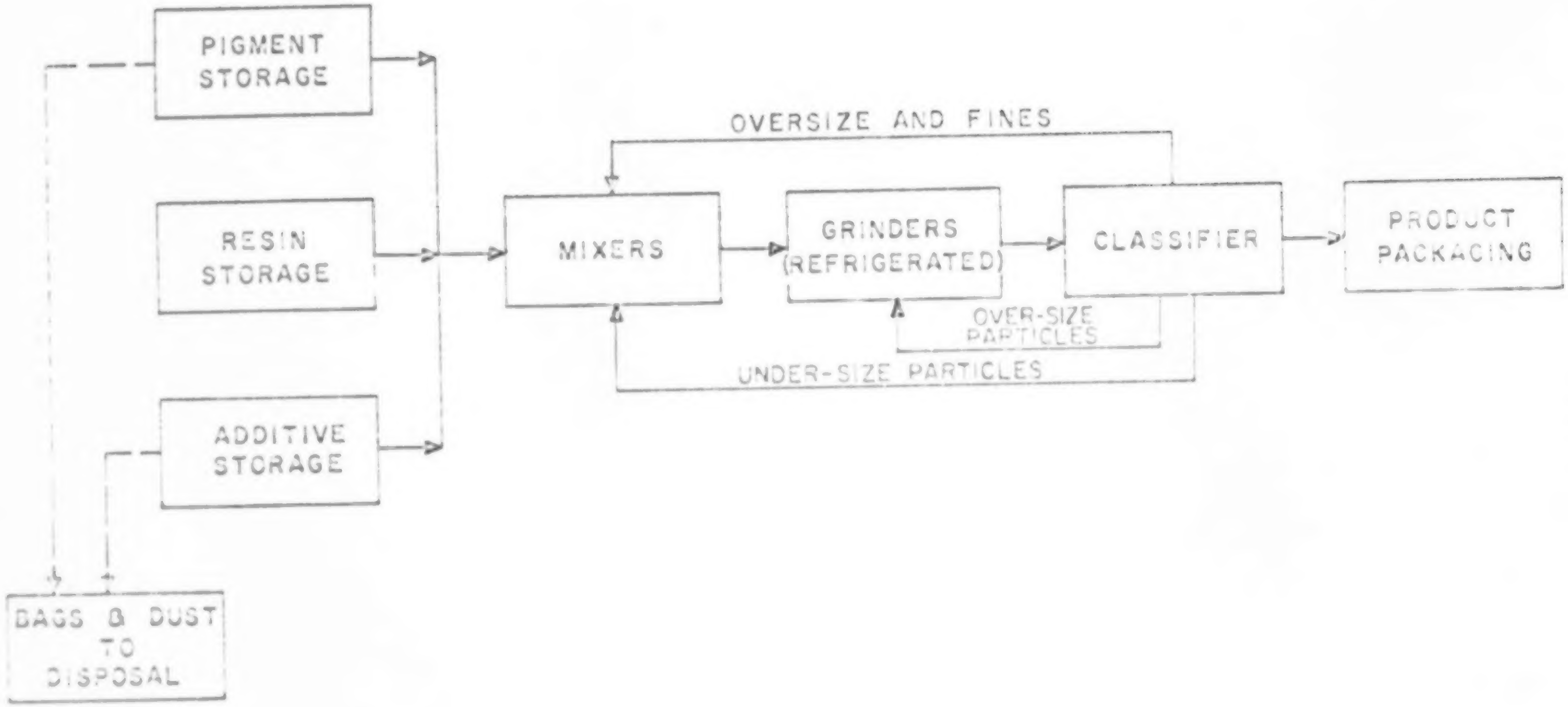

PIGMENT STORAGE
RESIN STORAGE
ADDITIVE STORAGE
BAGS & DUST TO DISPOSAL
MIXERS
GRINDERS (REFRIGERATED)
CLASSIFIER
PRODUCT PACKAGING
OVERSIZE AND FINES
OVER-SIZE PARTICLES
UNDER-SIZE PARTICLES

FIGURE 11

POWDER COATINGS MANUFACTURING FLOW DIAGRAM

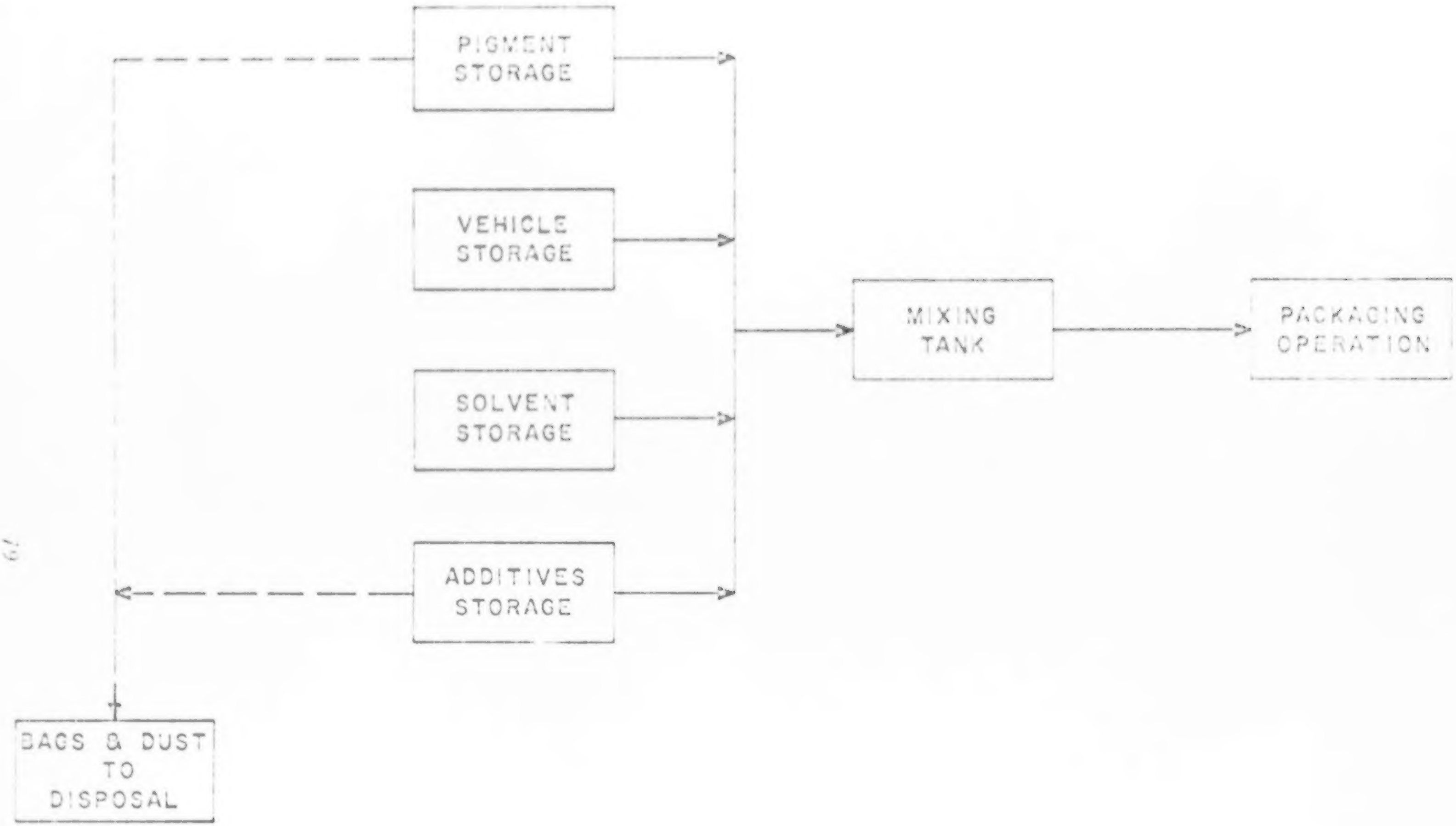

PIGMENT STORAGE
VEHICLE STORAGE
SOLVENT STORAGE
ADDITIVES STORAGE
MIXING TANK
PACKAGING OPERATION
BAGS & DUST TO DISPOSAL

FIGURE 12

PUTTY MANUFACTURING FLOW DIAGRAM

nature from one product to another to preclude useful discussion here. It includes several hundred different products, no one of which constitutes as much as 10 percent of the total miscellaneous products. A fairly large proportion of these materials derives from repackaging already manufactured products, possibly with some thinning or tinting. In some cases, the products are manufactured and packaged by some other company, under the label of the seller, and the seller acts merely as an agent. Many aerosol products are handled in this fashion. Most of these operations do not lend themselves to flow diagrams.

Typical Formulation

A typical putty formulation is shown in Figure 13. The only real difference between putties and calking compounds is in the consistency. Calking compound, which is usually thinner in consistency, is normally applied with a calking gun, while a knife is utilized for putty. Less solvent and frequently no drier is used in calking compound. In the past, putty was often made from calcium carbonate and linseed oil, and, occasionally, white lead. The latter was added to produce a harder putty, but this practice has been discontinued. Today mineral oil has to a large extent replaced linseed oil in "commercial putty" since this makes it very easy to apply and is favored by commercial glaziers. However, this formulation remains very soft indefinitely and is easily marred.

There are no "typical" formulations for sufficient quantities of miscellaneous paint products to serve a useful purpose here.

Waste Sources

As noted earlier, the processes used in manufacturing paints do not in themselves create wastes. However, there are five principal sources of process wastes. They are (a) raw materials packaging; (b) sludges from water pollution control equipment; (c) solids from air pollution control equipment; (d) discarded finished products and spills; and (e) wash solvents.

These are discussed in this order in this portion of the report. However, in the subsequent section on waste quantities, data on wash solvents and wastewater sludges are combined and information on discarded waste products is broken down into spoiled batches and spills. Reasons for this presentation will be set forth in introducing the tables on waste quantities.

All of these wastes are batch wastes. The only one which can be related in quantity to the amount of product produced is raw materials packaging since the amount is essentially proportional.

FIGURE 11

TYPICAL PUTTY FORMULATION

MATERIAL	COMPOSITION WEIGHT PERCENT
PIGMENTS:	
CALCIUM CARBONATE	25
CLAY	25
VEHICLE:	
VEGETABLE OIL	35
SOLVENT:	
MINERAL SPIRITS	10
ADDITIVES:	
COBALT AND ZINC DRIER	5
	100

Raw Materials Packages

Pigments are usually supplied in 23-kg (50-lb) multi-wall paper bags. A few large operations, particularly water-thinned paint manufacturers, may obtain a portion of their pigments in bulk, usually as a water slurry, but this represents a very small part of the total. Some expensive pigments, used in small quantities, may be delivered in steel or plastic 19-liter (5-gal.) pails. Dry resins are usually also supplied in paper bags. Semi-solid or liquid resins come either in pails or 208-liter (55-gal.) steel drums. Most additives and specialty solvents arrive in pails or drums. The commoner solvents are usually delivered in tank wagons, directly into bulk storage. Some plants handle oils and some resins in this manner. Containers -- pints, quarts, gallons, etc. -- are usually wrapped in kraft or similar paper or in transparent plastic. Many of these materials are delivered on wooden pallets, handled by forklift trucks.

While raw materials packaging, attendant wrappings, pallets, etc., may account for approximately 65 percent of the total solid wastes of a paint plant, none of the packaging materials is hazardous and the only associated potential hazard is the small amount of pigment or other material that is not cleaned out of a bag or other container. It has been estimated, and confirmed by tests at two paint companies, that 28 to 56 gr (1 to 2 oz) of material remain in an emptied bag which held 23 kg (50 lb) of delivered material. When this residual material is classified as hazardous by application of the criteria set forth in this section, then the entire portion of the waste stream containing it is designated as potentially hazardous. When the contents of a container are an innocuous material such as titanium dioxide (TiO_2), that portion of this waste stream in non-hazardous.

This can be illustrated by examining the raw materials packaging in a typical large plant producing 3,800,000 liter (1,000,000 gal.) of paint per year -- including trade sales water- and solvent-thinned paints and factory-applied coatings. The total bag waste (not including wrapping, pallets, etc.) will amount to about 34 kkg (37 tons); of this, only about 2.0 kkg (2.2 tons) will constitute a hazardous waste stream. This includes approximately 0.1 kkg (0.1 ton) of toxic chemical material and 1.9 kkg (2.1 ton) of bags containing this material. The remaining 32 kkg (35 tons) is accounted for by bags containing TiO_2 along with clays and other innocuous extender pigments. All these wastes are essentially dry materials with a moisture content of less than five percent.

Segregation of the toxic and innocuous streams is rarely practiced and therefore the hazardous constituents of the combined waste stream are usually dilute. This will vary, however, from plant to plant and from batch to batch in the same plant depending upon the raw materials of the products being manufactured. For example, in a light blue paint phthalocyanine blue, a potentially hazardous substance, may constitute one percent of the pigment with TiO_2 and extender pigment accounting for the other 99 percent. The production of blue paint may, at one time, constitute one percent or less of the total plant production. At other times, it could represent the majority of the plant's output.

Sludges from Water Pollution Control Equipment

Water pollution control in paint plants usually consists of wastewater sedimentation, sometimes aided by a flocculant. The wastewaters treated derive from the production of water-thinned paints which, compared to solvent-thinned products, contain only a few hazardous materials.

This is particularly true of white water-based paint in which the pigments used today are non-hazardous (mostly titanium dioxide), and the hazardous potential consists of not more than 0.01 percent of mercurials which may be used as a preservative and fungicide. The sludges from colored water-based paint also contain a small amount of pigments (up to about five percent) classed as potentially hazardous materials.

Thus, while this waste stream is a minor one, it is considered potentially hazardous. In the typical plant producing 3,800,000 liters (1,000,000 gal.) per year described above, this waste stream represents approximately 85 kkg (94 tons) of cleanings -- 12 kkg (13 tons) dry weight -- which contain 0.6 kkg (0.7 ton) of toxic chemical constituents.

Solids from Air Pollution Control Equipment

When air pollution control equipment is used in paint plants, it is usually limited to an air filter. Dust accumulated from operations such as the emptying of raw materials bags consists almost entirely of pigments and is primarily composed of non-hazardous extender pigment such as calcium carbonate. There is no segregation of hazardous and non-hazardous dust. Dust from 13 air filter units indicate that 2.2 kg (4.9 lb) of dust are collected in the production of 2800 liters (1000 gal.) of paint. In the above typical plant this would amount to about 2 kkg (2 tons) per year and would contain about 0.1 kkg (0.1 ton) of toxic pigment. It is thus characterized as a potentially hazardous waste stream.

The use of such a mixture of dusts is restricted in that it can only be used in low grade products. In most cases it is more economical to discard this dust along with other solid wastes and only small quantities are used at present. These wastes are dry with a moisture content of less than five percent.

Waste Products

This category of wastes consists of finished products which are not saleable and cannot be economically reworked into some useful form. They include small quantities of spoiled batches, spills, unsold warehouse stocks, and retained samples which contain a wide variety of materials.

Spoiled batches can normally be returned to process in a later product and are discarded only in occasional instances where product quality specifications are too stringent. The total quantity of spoiled batches disposed of by 59 surveyed plants over a 12-month period amounted to 162,000 liters (43,000 gal.) or 0.2 percent of total production.

Spills are likewise salvaged to the extent possible and frequently the amount contained in or on final clean-up absorbent materials is the only quantity discarded. Fifty-seven surveyed plants reported a 12-month total of 23,000 liters (6000 gal.) of spilled material discarded.

Warehouse stocks which have not been sold within their expected shelf life and which are packaged in larger containers may be reclaimed. However, it is not economical in labor and time to open and empty for reuse .5-liter (1-pt) cans of retained samples or unsold merchandise in containers of 3.8 liters (1 gal.) or less.

The quantity of finished product wastes generated by a paint plant is not a function of the amount of paint produced. It is instead a measure of the level of care and housekeeping in a given plant, of the kind of products manufactured, or a combination of these factors. For example, manufacture of factory-applied coatings generally produces a much greater quantity of product wastes than the production of other types of coatings because of more demanding quality control, particularly in color, and there are rarely second-line products to absorb spoiled batches. On the other hand, although larger in volume these wastes contain little or no metallic driers since they are not commonly used in industrial coatings. Paints which do contain significant amounts of toxic metals usually generate fewer product wastes because the cost of these materials often justifies more effort to rework them.

The vast majority of paint plants manufactures more than one type of coating, and the resulting product wastes, while generated separately, are not commonly segregated for storage and disposal. Thus the total of all waste products is characterized as a potentially hazardous waste stream because these products may contain any of a great diversity of toxic chemicals and/or flammable materials, ranging through the whole gamut of paint raw materials so classified. These substances are usually present in small amounts which will vary from plant to plant, and from product to product.

In the typical plant producing 3,800,000 liters (1,000,000 gal.) of mixed product annually, spoiled batches and spills would amount to about 10 kkg (11 tons) per year containing 0.4 kkg (0.5 ton) of hazardous solvents and 0.05 kkg (0.06 ton) of other toxic chemical constituents.

Waste Wash Solvents

When equipment is to be shut down, or a substantial change in color or type of product is planned, the paint remaining in the equipment must be removed. In the case of organic solvent-based products, a suitable solvent is used for the wash-up. It may be the same solvent used in the manufacture of the product, although in many cases material with a higher boiling point but essentially the same solvency may be used (mineral spirits for a product dissolved in VM&P naphtha, for instance). The higher-boiling solvents are usually cheaper and there is less loss by evaporation.

There is little relationship between the amount of paint manufactured and the volume of solvent washings which require disposal. As frequently as it is feasible, the solvent is retained and reused in a later product. In other cases, the solvent is reclaimed on-site either through distillation or sedimentation or is sent to a contract reclaimer who processes the material and then returns it for reuse. Only the still bottoms from on-site reclamation are included with and quantified as plant wastes. Contaminated solvent sent to a solvent reclaiming contractor is deducted from the wastes of the paint manufacturing industry.

In the case of water-thinned paints, equipment is usually washed with water, possibly with an added detergent. Since water is an inexpensive solvent, relatively large quantities can be used in washing and the concentration of solids in water washes will be low. However, where wastewater treatment is practiced, the settled sludge will have a high solids content (about 10 percent). In cases where wastewater will not be acceptable to a municipal sewer after treatment, more intensive use is usually made of the wash water as a thinner in subsequent batches of the same type of paint. Not all wastewater can be used in this manner, however, since problems of color and compatability may arise. In particular, the color of the wastewater and the color of the material in which it is used should not seriously differ. Wash water from very dark colors, experimental or spoiled batches, or other unusual materials must usually be drummed and deposited in a landfill.

In a typical 3,800,000-liter (1,000,000-gal.) per year plant producing both water- and solvent-based products, about 85 kkg (94 tons) of cleaning wastes -- 62 kkg (68 tons) dry weight -- would be generated per year. This waste material would contain approximately 9 kkg (10 tons) of hazardous solvents and 0.6 kkg (0.7 tons) of toxic chemicals.

Because there is no segregation of waste wash solvents to isolate those containing no hazardous constituents, all washings are considered potentially hazardous.

Raw Materials Usage

Paint is a dispersion of pigment in a liquid "vehicle." The vehicle consists of a volatile solvent and a non-volatile portion called the binder. Organic solvents or water may be used as the former and resins or oils function as a binder (2)(3)(4). This section briefly describes the nature of these principal paint components and includes detailed lists of the estimated quantities of the actual materials used. Physical and chemical properties of the major raw materials are provided in Appendix D, while discussions of the uses of these materials are given in Appendix H.

Pigments

Pigments are, in general, finely divided, insoluble organic and inorganic powders which contribute color, opacity, consistency, and durability to paint. They may be described as white, transparent, colored, and metallic. The pigment section of the NPCA Raw Materials Index (19) lists several thousand different materials, but many of these differ only slightly in color, particle size, or surface treatment. There are probably five hundred different pigments available to the paint industry, many of which are used in only very small amounts for specialty products. The amount of pure pigments required can be reduced by the use of cheaper materials which are classified as extenders. These include calcium carbonate and talc. Table 15 lists the major pigments used in paint and coatings and shows estimated usage in 1972. This table was derived from the NPCA Raw Materials Usage Survey (20). The reported usage listed in this publication is estimated to represent about half of actual usage and the total amounts shown in the table were estimated on this basis.

Resins

Resins are the usual binders which contribute to the durability, adhesion, flexibility, and gloss of coatings. They may be purchased either as solutions or as solids and fall into three general classes -- 1) those used in lacquers which dry purely by the evaporation of solvent (cellulose derivatives, acrylic, vinyl, and bituminous resins); 2) those which dry by a chemical reaction with air (alkyds) or moisture (urethanes); and 3) those which dry (or set) at high temperature (phenolics and others). Many coatings involve blends of more than one type of resin, and the division between classes is not always sharp. The Resin

TABLE 15

ESTIMATED
PIGMENT USAGE BY PAINT INDUSTRY, 1972[a]

	USAGE	
	million lbs/yr	thousand kkg/yr
LEAD		
*Basic lead carbonate	0.91	0.41
*Basic white lead silicate	2.44	1.10
*Red lead	5.94	2.70
*Other lead pigments	4.70	2.13
WHITES		
*Antimony oxide	0.52	0.24
Lithopone	4.78	2.17
Titanium dioxide, pure	592.69	268.84
Titanium dioxide, extended (usually 50% TiO_2)	26.26	11.91
*Zinc oxide, leaded	0.70	0.32
Zinc oxide (pure)	22.22	10.08
Other white pigments	0.71	0.32
BLACKS		
Carbon black	6.08	2.76
Lamp black	2.03	1.00
Other black pigments (except black iron oxide)	1.57	0.77
YELLOWS and ORANGES - INORGANIC		
*C.P. cadmium oranges and reds	0.07	0.04
*Cadmium lithopone	0.04	0.02
*Chrome yellow	29.06	14.35
*Molybdate orange	5.02	2.48
*Strontium chromate	0.64	0.32
*Zinc chromate	7.33	3.62
Other inorganic yellow and orange pigments	9.17	4.53
Organic yellows and oranges	1.67	0.83
BLUES and VIOLETS		
Iron blue (Milori-Chinese-Prussian)	0.55	0.27
Ultramarine blue	0.49	0.24
Other inorganic blues and violets	0.10	0.05
*Phthalocyanine blue	1.14	0.56
Other organic blues and violets	0.13	0.07

---

*Indicates hazardous materials.

[a] Based on National Paint and Coatings Association Raw Materials Usage Survey (20).

TABLE 15 - cont'd.

	USAGE	
	million lbs/yr	thousand kg/yr
GREENS		
*Chrome green	0.90	0.44
*Chromium oxide and hydrated chromium oxide	2.31	1.14
*Phthalocyanine green	1.09	0.54
Pigment green B	0.02	0.01
REDS and MAROONS - INORGANIC (except iron oxide)	3.68	1.82
REDS and MAROONS - ORGANIC		
B. O. N. maroon	0.37	0.17
Chlorinated para reds	0.21	0.10
Lithol red and rubine	0.15	0.07
Other organic reds and maroons	3.98	1.80
FLUSHED COLORS	2.48	1.12
AQUEOUS DISPERSIONS		
Hansa yellow	0.84	0.38
Iron oxides	12.51	5.67
*Phthalocyanine blue	0.41	0.18
*Phthalocyanine green	0.49	0.22
Toluidine red	0.11	0.05
Other aqueous dispersions	5.38	2.44
Other pigment dispersions	5.85	2.65
METALLIC		
Aluminum pastes	10.70	4.85
Aluminum powder	0.33	0.15
Bronze powders	0.21	0.09
*Copper powders	0.16	0.07
Other metallic flakes	0.80	0.36
IRON OXIDES		
Synthetic iron oxides (reds)	12.91	5.86
Synthetic iron oxides (yellows)	17.46	7.92
Synthetic iron oxides (other)	4.95	2.25
Natural iron oxides	6.05	2.74
Ochres, siennas, and umbers	3.41	1.55
EXTENDERS		
Calcium carbonate - precipitated	75.78	34.37
Calcium carbonate - natural	185.18	84.00
Magnesium silicate (talcs)	137.11	62.19
Barytes - natural	50.02	22.69
Diatomaceous earths	31.11	14.11

TABLE 15 - Cont'd.

EXTENDERS - Cont'd.	USAGE million lbs/yr	 thousand kkg/yr
Koalin (calcined and other clays)	160.17	72.65
Mica, dry and water-ground	20.14	9.14
Silicas, ground	154.56	70.11
Other extender pigments	75.66	34.32
MISCELLANEOUS		
*Cuprous oxide	3.35	1.52
Fluorescent pigments	0.15	0.07
Zinc dust	28.59	13.00
Other miscellaneous pigments	4.78	2.17

Section of the NPCA Raw Materials Index (21) lists approximately thirty different types of resins, many of which are primarily used by other industries.

Table 16 shows estimated resin usage by the U.S. paint industry in 1972. This table was also derived from the NPCA Raw Materials Usage Survey (20) in the manner described above.

Oils

Traditionally, before the present resins were developed, drying oils -- primarily linseed with lesser amounts of soybean, tung, oiticica, perilla, and dehydrated castor -- were used as paint vehicles, either by themselves or cooked with natural resins as varnishes. The newer resins, some of which (particularly alkyds) incorporate some of these oils, have largely replaced the straight oils in everything except outside house paints. Due to cost advantages, the decline in consumption of oils by the paint industry of recent years is expected to continue. A few non-drying oils, such as coconut and cottonseed, are used in small amounts, usually in alkyds. Quantities of various oils used in paints in 1972 are given in Table 17.

Solvents

The primary function of solvents used in coatings is to adjust the viscosity for easy application. Since the solvent does not form a part of the final film and contributes little to the properties of that film, the cheapest material which will dissolve the resin and will evaporate at the desired rate is usually chosen. Other properties which are sometimes considered in the choice of solvents include odor, air pollution control regulations, and "solvent balance." This term means that if a mixture of solvents is used, they should be chosen so that any change of solvency due to the lower boiling solvent coming off first, will not have an adverse effect on the performance of the coating. Other things being equal, a petroleum fraction of suitable boiling range -- mineral spirits, VM&P naphtha, textile spirits, etc.-- are used. When these will not dissolve the resin, aromatic solvents, such as toluene or xylene, esters (ethyl acetate, etc.), or ketones (methyl ethyl ketone, etc.,) are employed. A few alcohol-soluble resins, such as shellac, are dissolved in ethanol or isopropanol. Water is used for a few water-soluble resins, and to thin emulsions. Small amounts of other solvents are used in paint and varnish removers, spirit stains, and other miscellaneous materials. Solvent usage in the paint industry in 1972 is summarized in Table 18.

Plasticizers

Many of the resins used by the coatings industry, such as cellulose

TABLE 16

ESTIMATED
RESIN USAGE BY PAINT INDUSTRY, 1972[a]

	USAGE	
RESINS FOR SOLVENT-THINNED VEHICLES[b] *	million lbs/yr (Dry Weight)[c]	thousand kkg/yr
Acrylic, lacquer type	8.41	3.82
Acrylic, thermo-setting type	43.36	19.67
Alkyds	211.41	95.89
Epoxy resins	68.84	31.22
Epoxy ester resins	7.27	3.30
Hydrocarbon resins	19.10	8.66
Maleic resins	7.27	3.30
Phenolic resins, pure	9.84	4.46
Polyurethane resins	12.99	5.89
Silicone resins	2.85	1.29
Urea and melamine formaldehyde resins	16.50	7.48
Vinyl (formal and butyral) acetal resins	4.22	1.91
Vinyl acetate solution-type copolymers	9.65	4.38
Other solvent-phase resins	14.85	6.74
WATER EMULSIONS *		
Acrylic emulsions	215.03	97.53
Casein	1.01	0.47
Polyvinyl acetate emulsions	89.81	40.74
Polyvinyl chloride emulsions	0.42	0.19
Styrene-butadiene emulsions	3.18	1.44
Other emulsions	60.55	27.46

Cont'd.

---

[a] Based on National Paint and Coatings Association Raw Materials Usage Survey (20).

[b] Substantial amounts of cellulose nitrate, cellulose acetate, cellulose butyrate, and ethyl cellulose are used as resins in coatings, particularly lacquers. However, production data on these products are withheld to protect the interests of a very limited number of producers.

[c] Most of these resins are normally sold in solution, so, on the average, it can be assumed that they are accompanied by an equal weight of solvent.

*None of these materials are considered hazardous.

TABLE 16 - Cont'd.

	USAGE	
WATER-SOLUBLE RESINS*	million lbs/yr (Dry Weight)[c]	thousand kkg/yr
Water-soluble oil and alkyd types	6.56	2.97
Other water-soluble types	0.54	0.24
MISCELLANEOUS*		
Asphalt and coal-tar pitch	64.71	29.35
Chlorinated paraffins	1.23	0.56
Natural resins (Manila, Dammar, Copal, etc.)	2.46	1.12
Shellac	0.32	0.14
Waxes	6.22	2.82
Other miscellaneous resins and polymers	5.35	2.52

TABLE 17

ESTIMATED
DRYING OIL USAGE BY PAINT INDUSTRY, 1972[a]

OILS*	USAGE million lbs/yr	USAGE thousand kkg/yr
Castor oil, raw	3.50	1.59
Castor oil, dehydrated	8.08	3.67
Tung oil	15.21	6.90
Coconut oil	6.24	2.83
Linseed oil	88.63	40.20
Safflower oil	15.32	6.95
Soybean oil	62.16	28.20
Fish oil	1.17	0.53
Other oils	22.22	10.08
FATTY ACIDS*		
Coconut	0.62	0.28
Linseed	6.06	2.75
Soybean	4.55	2.06
Tall oil	46.87	21.26
Other fatty acids	8.36	3.79

---

[a] Based on National Paint and Coatings Association Raw Materials Usage Survey (20).

*None of these materials are considered hazardous.

TABLE 17

ESTIMATED SOLVENT USAGE BY PAINT INDUSTRY, 1972[a]

	USAGE	
	Million gal./yr	Million liters/yr
ALIPHATIC HYDROCARBONS		
*Mineral spirits, regular and low odor	63.74	241.26
*Mineral spirits, odorless	12.28	46.48
*Kerosene	1.66	6.28
*Mineral spirits, heavy	5.17	19.57
*Other aliphatic hydrocarbons	30.69	116.16
AROMATIC and NAPHTHENIC HYDROCARBONS		
*Benzene	0.96	3.63
*Toluene	52.73	199.55
*Xylene	66.92	253.29
*Naphtha, high flash	13.90	52.61
*Other aromatic hydrocarbons	29.57	111.92
TERPENIC HYDROCARBONS (Pine Oil and Turpentine)	0.98	3.71
KETONES		
*Acetone	134.70	509.84
*Methyl ethyl ketone (MEK)	144.78	547.99
*Methyl isobutyl ketone (MIBK)	57.75	218.58
*Other ketones	10.29	38.94
ESTERS		
*Ethyl acetate	6.01	22.75
*Isopropyl acetate	5.81	22.14
*Normal butyl acetate	65.36	247.39
*Other esters	43.12	163.21

---

[a] Based on National Paint and Coatings Association Raw Materials Usage Survey (29).

*Indicates hazardous material.

nitrate, many phenolics, vinyls, and others, are, by themselves, too brittle to have adequate adhesion or exterior durability. For that reason, they are usually mixed with plasticizers, a procedure which will yield flexible films. The plasticizers are relatively soft materials which resist oxidation on exposure and provide continuing compatibility with the resin so it will remain plasticized. One must be selected which will not come off the film at high temperatures. Some of the common plasticizers are esters, such as castor, or polymerized oils. Alkyds made with non-drying oils are often used to plasticize urea resins. While these materials are sold under numerous trade names, they are all manufactured by a very limited number of companies. For this reason, the confidentiality of plant data is protected by the Bureau of the Census and other data sources. Therefore, few figures are available on plasticizer use.

Additives

A wide variety of materials are added to many paint formulations in small amounts for specific purposes. Driers are used to accelerate the oxidation (or "drying") of drying oils and alkyd resins. They are organic soaps of cobalt, lead, manganese, or other metals. The organic portion confers solubility in the organic solvents used, but otherwise does not appear to affect the catalyst properties which are determined by the metal. A few non-metallic materials are also used as driers.

Anti-skinning agents are the reverse of driers in that they delay the drying of oils or alkyds in the can with the formation of a "skin." They are usually volatile, so that they evaporate rapidly after the coating is applied.

Various mercury compounds have, historically, been used as preservatives and fungicides. Water-thinned paints are, for various reasons, excellent food for many bacteria and, without a preservative, many of these paints will decay in the can. Both water- and solvent-thinned paints are susceptible, after application, to an assortment of fungi, which are often called "mildew," although there is some doubt about this nomenclature. Mercury is effective, both as a bactericide and a fungicide, and, for that reason, is preferred by paint manufacturers. Although a wide variety of non-mercurial bactericides and fungicides are available, they rarely perform both functions and their durability on exposure have been found to be poor compared to that of mercury compounds.

A wide variety of materials, generally classified as surface-active agents, are used to adjust the mixing and dispersing of pigments, consistency of the paint, settling properties, ease of application, and flow and levelling of the applied coatings. These are often proprietary compounds whose composition is not disclosed. The proper use of these materials is more an art than a science, and often small amounts of several may be used in the same formulation.

Finally, small amounts of zinc stearate are often used to improve the sanding properties of sanding sealers.

Total paint industry miscellaneous materials usage is estimated for 1972 in Table 19.

Physical/Chemical Properties of Raw Materials

A literature search was employed to establish the physical/chemical properties of raw materials reported in use by surveyed paint plants which will influence their potential environmental behavior when disposed of on land. These data appear in Appendix D. There are occasional gaps in this table which are explained by the fact that after a reasonable search no reliable references were found to establish one or another characteristic of a particular compound.

Appendix D lists compounds by both the chemical name and common name, gives the formula, and identifies the industrial use of each. The physical/chemical properties described include appearance, specific gravity, boiling point, melting point, water and alcohol solubility, flash point, toxicity rating, and threshold lethal value (TLV). None of these materials, so far as is known, contains radioactive, explosive, or biological ingredients.

Potentially Hazardous Materials

Before initiating paint plant surveys a working list of potentially hazardous materials was compiled. The list included, first, eight elemental substances and four classes of compounds which EPA believes, on the basis of initial analysis, to have the potential for producing serious public health and environmental problems when contained in wastes. They are:

Arsenic
Beryllium
Cadmium
Chromium
Copper
Lead
Mercury
Selenium
Zinc

Asbestos
Cyanides
Halogenated Hydrocarbons
Organic Pesticides

TABLE 19

ESTIMATED
MISCELLANEOUS MATERIALS USAGE, 1972[a]

	USAGE	
	million lbs/yr	thousand kkg/yr
ANTI-SKINNING AGENTS	4.90	2.23
METALLIC SOAPS		
Aluminum stearate	0.32	0.15
*Zinc stearate	1.52	0.69
Calcium stearate	0.23	0.10
Other metallic soaps	0.28	0.12
BODYING AGENTS, SOLVENT SYSTEMS (other than above)	4.91	2.23
BODYING AGENTS, WATER SYSTEMS		
Carboxymethyl cellulose (C.M.C.)	0.44	0.20
Hydroxethyl cellulose	9.34	4.23
Methyl cellulose	2.15	0.98
Others	2.37	1.08
DISPERSING and MIXING AIDS	25.51	11.57
DRIERS		
Calcium soaps	1.90	0.86
*Cobalt soaps	3.97	1.80
*Lead soaps	5.40	2.45
Manganese soaps	1.53	0.69
*Zirconium soaps	1.73	0.78
Other driers	1.55	0.70
FUNGICIDES, GERMICIDES, and MILDEWCIDES		
*Phenols, halogenated phenols, and their salts	0.41	0.19
*Phenyl mercuric acetate	0.88	0.40
*Phenyl mercuric oleate	0.19	0.09
Others	3.19	1.45

---

[a] Based on National Paint and Coatings Association Raw Materials Usage Survey (20).

*Indicates potentially hazardous materials.

The contractor added other substances which appeared to justify consideration. Those with a toxic chemical potential were: antimony, barium, and cobalt. In addition, low-flash solvents with a proclivity to flammability on land waste disposal sites, some of which are also moderately toxic, were included.

The list was incorporated into the plant survey format (Appendix A), the development of which is described in the "Methodology" section. This form was then used by survey personnel to elicit information from plant personnel on the names of specific compounds used which contain one or more of these substances. The information developed on the survey forms was used as the basis for the list of compounds shown in Table 20, which also summarizes available information on their toxicity. The numbers in parentheses are the references from which the data are drawn; the question marks indicate that the authors considered the data inadequate for an unqualified rating. Other toxicological reference works utilized are shown in the References (38 - 47).

It will be remembered that the criteria set forth previously for defining a material as potentially hazardous on the basis of its toxicity are: 1) it has a toxicity rating of 3 or above, according to Gleason, et al. (1); 2) it is rated as toxic by other reliable literature; 3) it contains one or more of the above substances and no reliable reference as to its toxicity was found. Application of these criteria results in the classification of all materials shown in Table 20 as toxic, and thus hazardous, except antimony trisulfide, zinc naphthenate, zinc peroxide, and ethyl acetate.

No surveyed plant employs compounds containing arsenic, beryllium, or cyanides.

Information on the industrial uses of specific potentially hazardous materials is shown in Appendix B.

TABLE 20

TOXICITY OF RAW MATERIALS USED IN SURVEYED PAINT PLANTS

	Toxicity Rating or Description
Antimony Trioxide	5 (1)
Antimony Trisulfide	Low toxicity (22)
Asbestos	Varies with form
Barium Carbonate	3, 4, or 5 (1)
Barium Lithol	No reference
Barium Metaborate	Low toxicity - No chronic effects
Cadmium Selenide	5* - 6 if inhaled (1)
Chlorinated Paraffin	No reference
Chlorinated Rubber	No reference
Chrome Oxide	3 (1)
Cobalt Naphthenate	No reference
Copper Naphthenate	3* (1)
Cuprous Oxide	4 (1)
Lead Carbonate	No reference
Lead Chromate	4 (1)
Lead Molybdate	3 (1)
Lead Monoxide	3 or 4 (1)
Lead Naphthenate	3* or 4 (1)
Lead Phosphate	Poisonous (23)
Lead Silicochromate	3
Lead Sulfate	No reference
Lead Tetroxide	3
Mercury Drier	No reference
Pentachlorophenol	4
PMA	5 (1)(Not substantiated by other literature)
PMO	No reference
Copper Phthalocyanine	No reference
Phenyl Mercuric Succinate	No reference
Strontium Chromate	Low order of toxicity (22)
Tributyl Tin Fluoride	No reference
Zinc Chromate	4 (After 6 months)(1)
Zinc Naphthenate	2 - 3
Zinc Peroxide	Similar to zinc oxide which is 2 - 3 (1)
Zinc Phosphate	No reference
Zinc Resinate	No reference
Zinc Stearate	3 (1)

---

*Indicates inadequate data for positive rating

TABLE 20 - Cont'd.

Solvents	Toxicity Rating or Description
Acetone	3 (1)
N-Butyl Acetate	3 (1)
Ethanol	2 (1)
Diacetone Alcohol	3 (1)
Ethyl Acetate	2-3 (1)
Heptane	Narcotic in high concentrations (22)
Hexane	3 (1)
Isopropanol	3 (1)
MEK	3 (1)
MIBK	3 (1)
Methanol	3 (1)
Mineral Spirits	3 (1)
Toluene	4(Toxic only at high concentrations)(1)
VM&P Naphtha	3 (1)
Xylene	3 (1)

Quantities of Potentially Hazardous Waste

The quantity of potentially hazardous wastes generated in the paint manufacturing industry is relatively small when compared to the amounts of such materials produced by some other major industries. The potentially hazardous substances used which become waste through the sources described earlier amount to about one-third of the total waste, although in some cases they constituted an entire waste stream under the definitions used in this report.

In order to determine current quantities of potentially hazardous wastes, the total waste produced in 1974 was first estimated. For purposes of this report, this total includes all wastes -- solid, semisolid, or liquid -- which were ultimately disposed of on land. It does not include materials which escaped to the ambient atmosphere or which entered a stream or municipal sewer system for disposal.

The potentially hazardous portion of the total waste is then quantified and the amounts of hazardous solvents and toxic chemical compounds contained therein are identified. While it is recognized that many of these solvents are toxic as well as flammable, they are segregated in all tabulations from other toxic substances so that disposal requirements for flammable materials can be more precisely determined.

The quantity of the potentially hazardous waste stream is identical to the total waste stream in case of waste products and spills, cleaning wastes, and dust collected in air pollution control equipment. This is because the potentially hazardous portion is distributed throughout the total stream and cannot be segregated in waste handling. This is not true of raw materials packaging where bags containing toxic chemical compounds can be separated from those containing non-hazardous substances and from other non-hazardous packaging materials such as cans or pails which are washed free of any potentially hazardous materials, drums which are sent for reconditioning, pallets, wrapping paper, etc.

On the other hand, the potentially total hazardous waste stream is greater than the sum of its hazardous solvent and toxic chemical constituents. This is because they similarly contaminate the larger body of waste and thus render the whole potentially hazardous.

The waste quantities estimated are extrapolations of information provided by the plant surveys. The methodology used in the various extrapolations is explained on a case-by-case basis. Quantities are expressed in metric tons containing 1016 kilograms (kkg); short tons (tons) of 2000 pounds; liters of 1.06 liquid quarts; and gallons of four quarts.

As discussed in Section III, most plants were able to supply figures for total production within ± 5 percent reliability. Raw materials usage was also generally reported, the accuracy of which depends on the inventory system used. It is estimated to be in the ± 10 percent range. In addition, some quantitative data were available on three potentially hazardous waste streams -- cleanings, raw material bags, and air pollution control residues -- and estimates were offered on spoiled batches and spills.

For purposes of this discussion of quantities, those streams are defined as follows:

1. Cleanings Stream -- All materials collected in the cleaning of mixing tanks, grinding equipment, transfer lines, pumps, can-filling machines, and small spills. These wastes may derive from water-thinned or solvent-thinned production or a combination of both depending on the type of products being manufactured. Quantities of cleanings presented in this report also include wastewater treatment sludges when these materials are included with the solid waste, but do not include sludges going directly to city sewers. This grouping is necessary because separate quantitative data are not available on wastewater treatment sludges and cleanings are their primary source. The small spills included in this waste stream are those involving less than 0.2 liter (1/2 pint) and splashes of paint.

2. Bags -- Manually emptied raw materials bags and small quantities of residual pigment or other material left in discarded bags. This stream does not include cans and drums which are cleaned, wrapping paper, or wooden skids used to handle raw materials.

3. Air Pollution Control Residues -- All dust and particulate matter collected in filter systems which are usually associated with the emptying of bags into process mixers. Small plants do not normally employ this equipment.

4. Spoiled Batch -- Spoiled batches of paint that go to disposal; normally, the majority of spoiled batches can be reworked into a different product and do not require disposal. Unusable spoiled batches tend to be concentrated in a small number of plants with particularly tight quality requirements.

5. Spills -- Large quantities of spilled paint collected with rags, saw dust, or some similar absorbent material. Although both spills and spoiled batches are finished products, spills are separated from spoiled batches because the paint in spills is diluted by a large quantity of non-hazardous absorbent material.

The quantity of spoiled batches and spills estimated during the plant surveys are necessarily experienced guesses by plant personnel because no monitoring equipment exists for their measurement. The accuracy of these quantities is believed to be ±50 percent. This broad spread does not introduce significant inaccuracies, however, since the hazardous materials from these sources constitute only six percent of the total potentially hazardous wastes.

Information on the quantities of total waste produced was often on a volume basis -- i.e., the volume of the waste container used times the frequency with which it is emptied. The conversion to total weight of solid and semi-solid waste is influenced by compaction equipment (if any) and on the contractural system employed. For example, some containers are emptied only when full and others after a fixed period of time regardless of the fractional content. Therefore, it was necessary to acquire as much information as possible on the individual character of each waste and handling method used to provide a basis for quantifying wastes for each plant. Fluids in the total waste were more accurately assessed in that they are usually contained within drums or tanks of known capacity.

Where estimates had to be made they were kept high so that wastes were not underestimated. Actual total waste quantities may vary from those given by as much as +5 percent to -20 percent. The skew distribution results from utilizing assumptions which maximize quantities. Table 21 summarizes assumptions made in analyzing the data.

Estimates of Total National Waste Quantities

Using linear extrapolation of survey plant data, it is estimated that a total of 388,000 kkg (428,000 tons) per year of waste were produced by the paint and coatings industry. The extrapolation is mainly in terms of plant numbers and production.

No relationship was found between waste characteristics and plant size in terms of number of employees (Figure 14), so this factor should not affect the accuracy of the extrapolation. While a random spread of characteristics was observed, no direct correlation could be identified.

In addition, investigation of plant age and elapsed time since major expansion or modification similarly revealed no influence of these factors on waste quantities. The results of this study are shown in Figures 15 and 16.

An investigation of waste characteristics versus geographic location also determined that this factor would not be likely to upset the above extrapolation of total waste.

The plant surveys in three areas of the country represent almost complete coverage of local paint manufacturing operations. Almost all of the Baltimore, Maryland paint plants were visited as were the majority of those in Dallas, Texas. In addition, eight of the 11 paint manufacturing plants in the state of Colorado were surveyed.

TABLE 21

CONSTANTS USED AND ASSUMPTIONS BASED ON DATA

Density Data	kg/liter	lb/gal.
Solvents:		
VM&P Naphtha	0.75	6.2
MEK	0.80	6.7
Toluene	0.86	7.2
Xylene	0.86	7.2
Textile Spirits	0.68	5.7
All Others	0.78	6.5
Paint	1.38	11.5
Epoxy	1.26	10.5
Putty	1.56	13.0
Dust from Air Pollution Control Equipment	1.50	30 lb/fiber drum
Drummed Solvent-Sludge Mixtures (based on 10% total solids concentration)	1.20	10.0
Loose Waste	0.12	200 lb/cu. yd.
Compacted Waste	0.30	500 lb/cu. yd.

Paint Manufacturing Industry Statistics	
Total Production	3.6 billion liters/yr 970 million gallons/yr
Total Employees	67,000
Production Employees	36,700

FIGURE 14

PLANT SIZE VS. TOTAL WASTE GENERATION

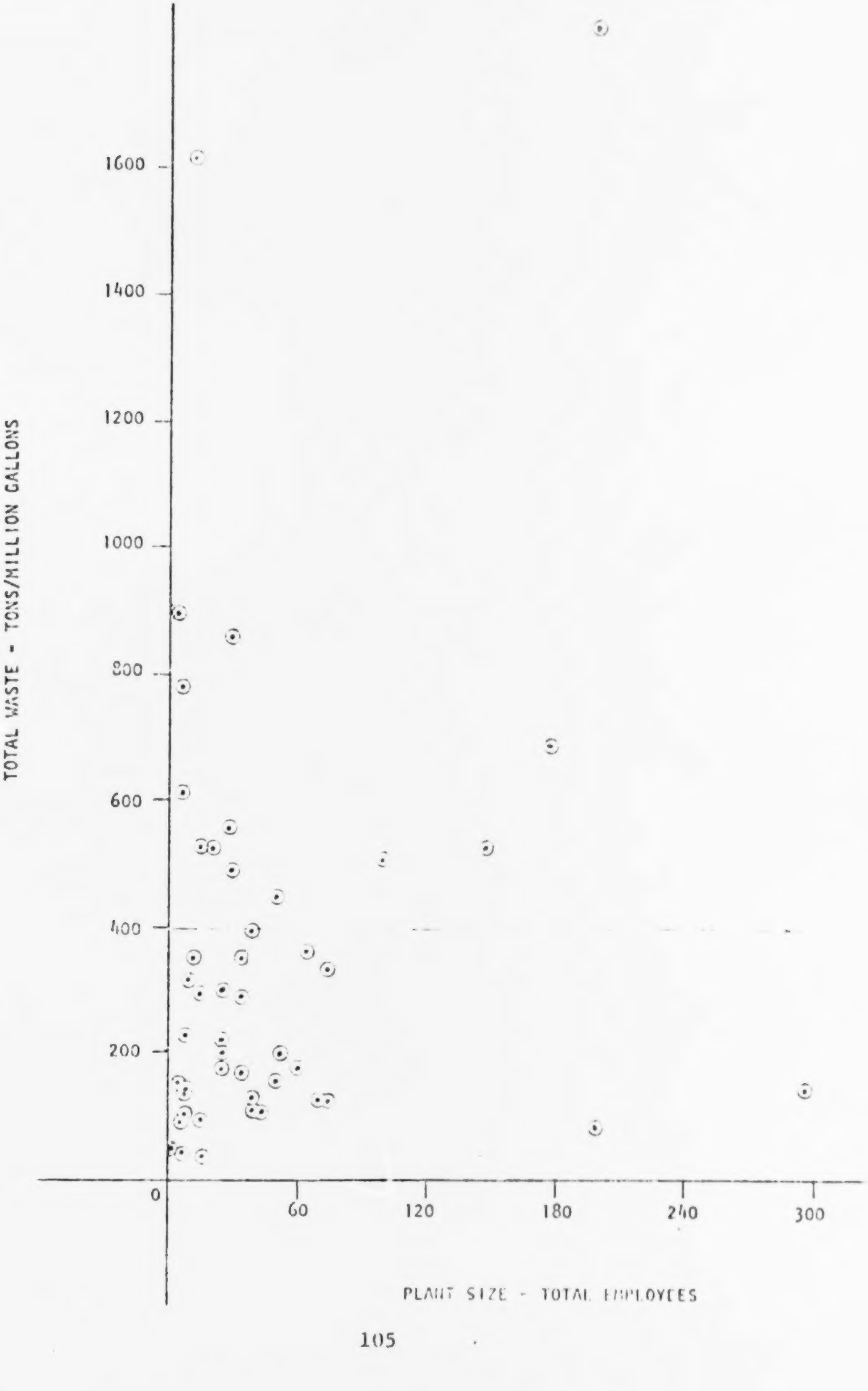


FIGURE 15

PLANT AGE VS. TOTAL WASTE GENERATION

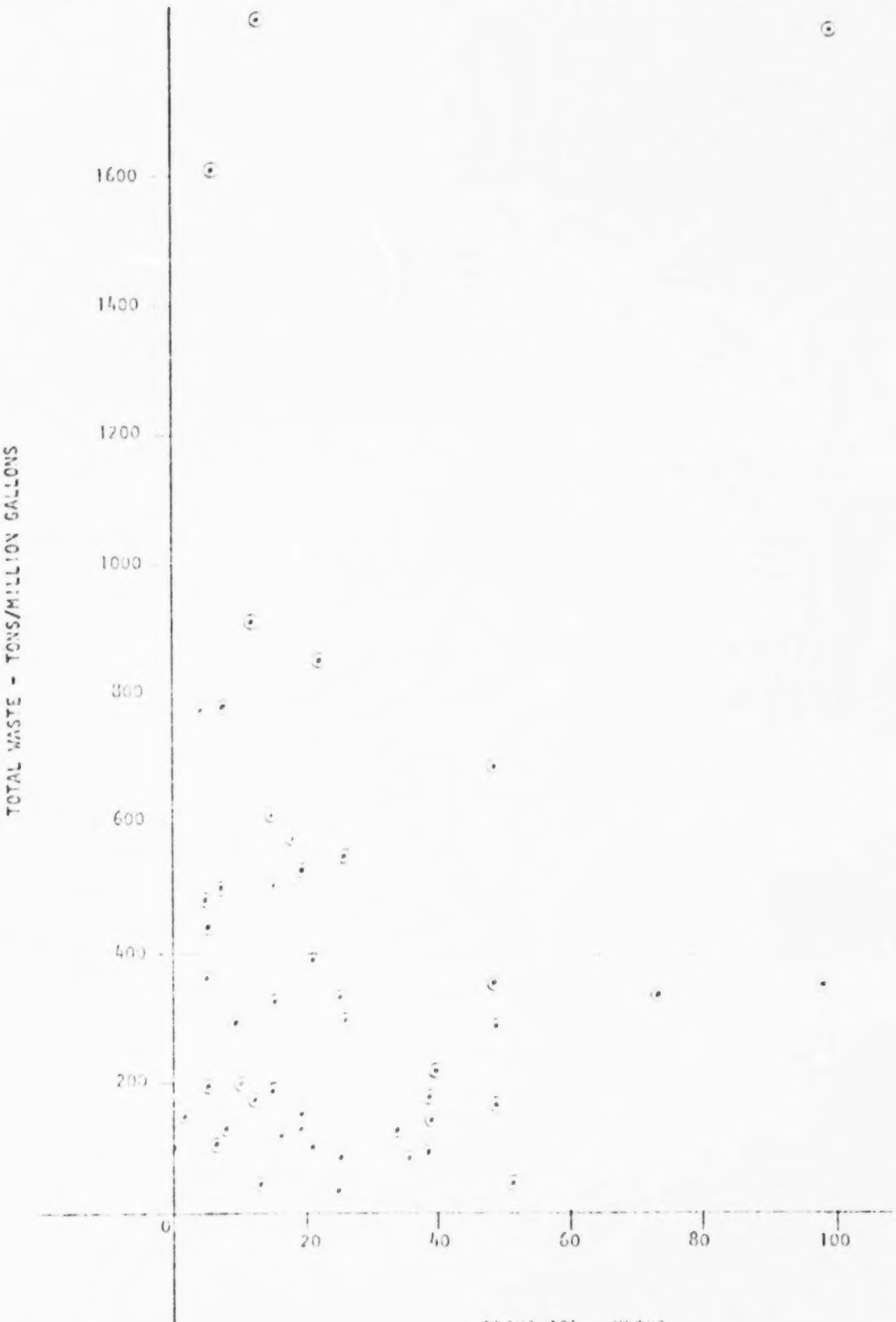
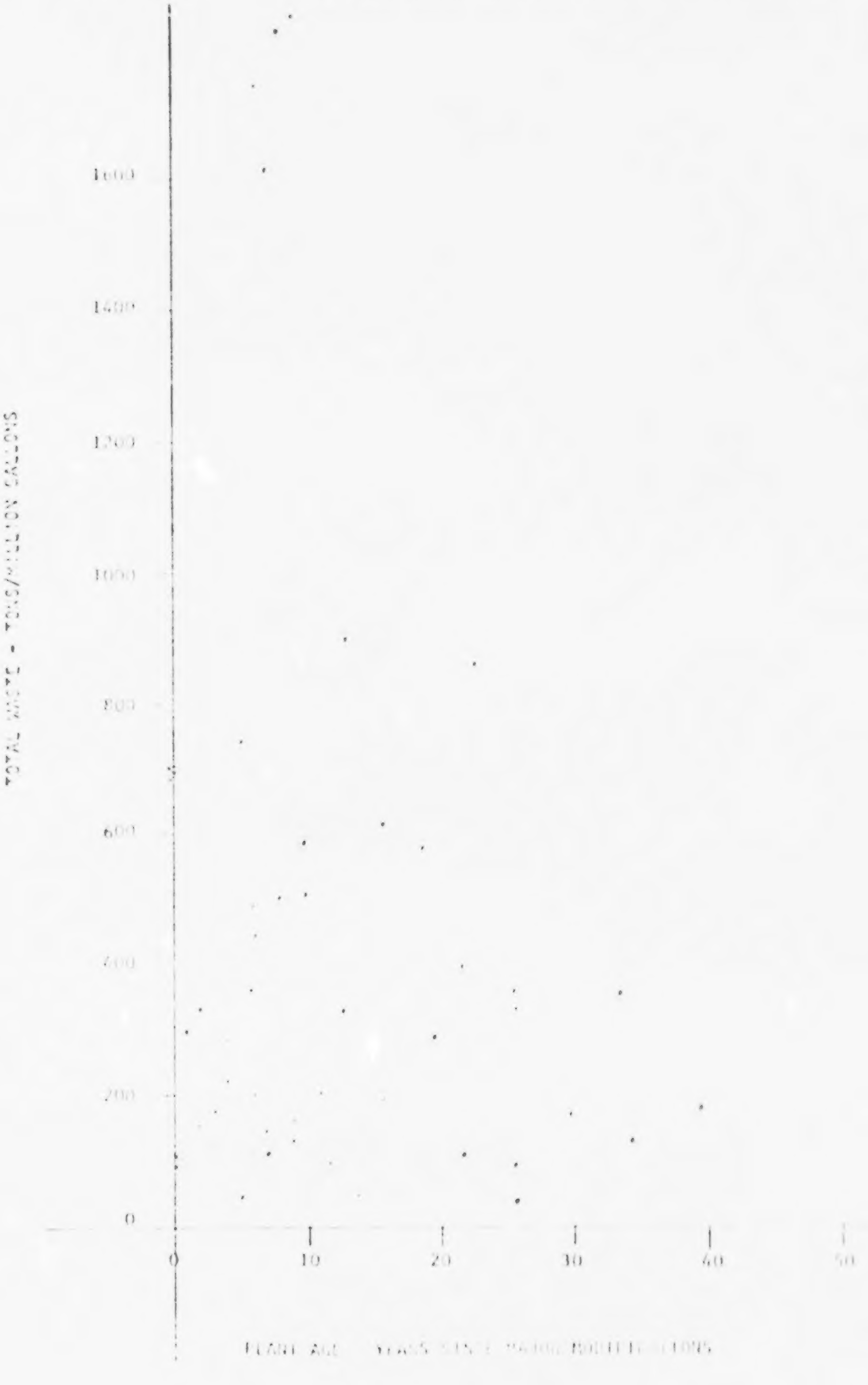


FIGURE 16

MODIFIED PLANT AGE VS. TOTAL WASTE GENERATION



Data parameters were averaged in each area to give regional characteristics and the three areas were compared. The average size of plants in the Baltimore area was found to be greater than for the other two areas, but an average time of 12 years since a major rebuild or modification was characteristic of all three areas.

Plants in the Colorado area were in general smaller in size than Baltimore or Dallas plants. The percentage of water-based paint production was similar in Dallas and Colorado but was lower in the older Baltimore area. The technology and materials used were similar in all areas.

A comparison of waste characteristics in the three areas did not reveal any significant differences. In Baltimore an average 334 kkg (368 tons) of waste were produced in the manufacture of 3.9 million liters (1 million gal.) of paint while in Dallas and Colorado areas the corresponding figures were 350 and 336 kkg per 3.8 million liters (386 and 370 tons per million gal.), respectively. Other waste parameters are correspondingly similar. Although these figures indicate a small variation, the spread of results is within the accuracy of the data used to compute these averages.

On the other hand, the characteristics of the waste produced by the manufacture of different types of paints will vary considerably. They were evaluated by selecting plants which concentrate almost all of their production on a particular type of paint and then averaging the waste characteristics from plants making similar products. The specific values of waste parameters are included in the discussions of each subcategory of paint products.

In extrapolating survey data parameters to obtain national figures, care was taken not to extrapolate non-representative data. For example, when one plant within the survey group was found to be a major contributor to any given parameter, the extrapolation excluded that particular plant and its contribution was then added to the result to give the national total.

Figure 17 illustrates the breakdown of the 1974 national waste total estimated above -- i.e., 389,000 kkg (428,000 tons) -- into total potentially hazardous wastes and total hazardous solvent and toxic chemical constituents. These breakdowns are based on plant survey data extrapolations. The national totals of spills and spoiled batches total 5400 kkg (6000 tons) per year and 4900 kkg (5400 tons) per year, respectively. The total cleaning stream is extrapolated to 67 million liters (18 million gal.) of spent organic solvents and wash water containing 583 kkg (643 tons) of solids. Solvents account for 40.1 million liters (10.6 million gal.) of the total fluid content. It is estimated that 13.6 million liters (3.6 million gal.) of this are reclaimed, leaving 26.5 million liters (7.0 million gal.) for disposal.

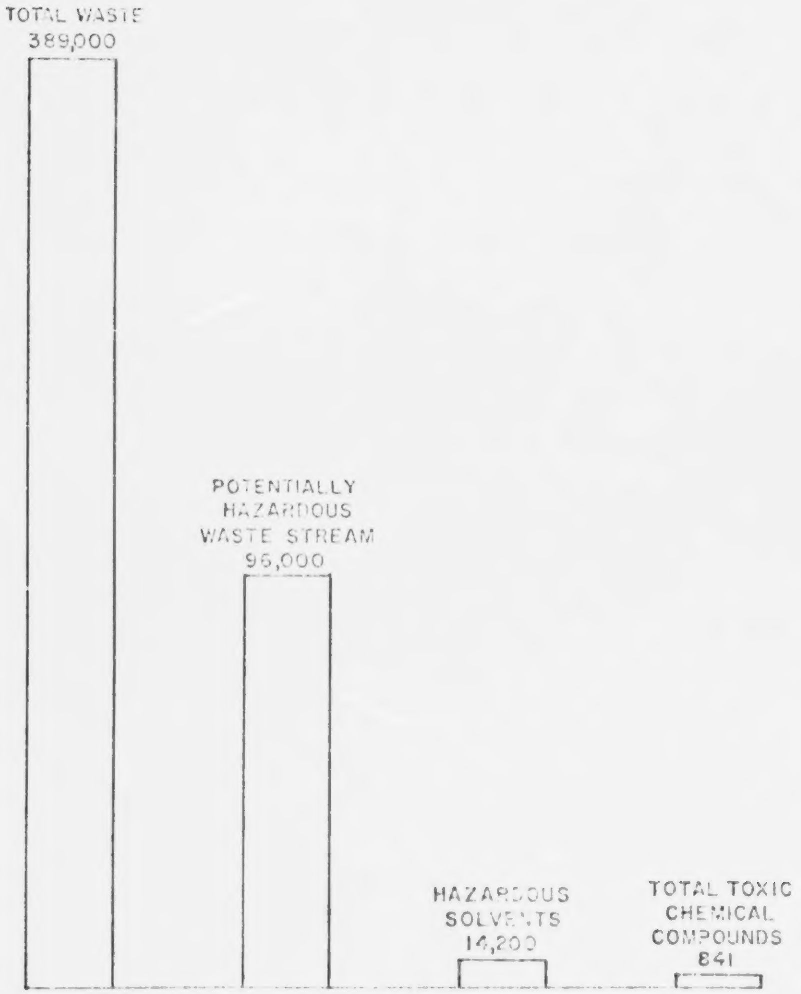


FIGURE 17

SUMMARY OF TOTAL QUANTITIES OF WASTE FROM PAINT AND COATINGS INDUSTRY

(kkg/yr)

(WET WEIGHT)

Total raw materials packaging wastes are comprised of 295,000 kkg (325,000 tons) per year of raw materials bags, residual pigments and other materials retained in them when they are emptied. Also included are steel or plastic pails, steel drums, wooden pallets, wire, wrapping paper and other packaging components. The hazardous portion of this waste stream is estimated at 2050 kkg (2250 tons) annually and consists of bags in which toxic pigments and other hazardous materials are delivered.

Dust from air pollution collection devices in the paint industry amount to 1600 kkg (1700 tons) per year, of which an estimated 81 kkg (90 tons) consists of hazardous materials.

The quantities are in substantial agreement with other studies of hazardous constituents in the wastes from paint manufacture (32)(33). They are also supported by the contractor's laboratory analysis of still bottoms from solvent reclamation operations which indicated relative proportions of elements similar to those shown in Figure 18. These analyses are discussed in the section of this report on reclaiming of solvents.

Estimates of Total Waste by State

The proportion of estimated national production in 1974 accounted for by a given state was used to estimate total waste quantities by state (Table 22). Since waste quantities do not necessarily correlate with production levels, the accuracy of the individual state figures is reduced, probably to the order of +15 percent to -35 percent for any individual state. Once again, the probable range is asymetrical because the assumptions made tend to maximize quantities.

Where states and combinations of states have very few paint plants and the projected quantity of a particular hazardous waste is very small, the accuracy of the extrapolation becomes even more questionable since one plant making a specialty paint not identified in this study could seriously affect the results. Hence, no figures are included where their reliability is not within 50 percent or where the quantity is significantly below 10 kilograms (22 pounds) per state per year.

It should be noted that, in some cases, comparable quantities in separate tables may differ, usually by less than one percent. This is due to rounding off data or applying factors to calculate waste quantities by state.

Waste Totals by EPA Region

Table 23 shows total 1974 waste quantities by EPA region. The foregoing explanations of the various waste streams are, of course, also applicable to this tabulation as well.

Wastes Generated by Industry Subcategory

Solvent-Thinned Trade Sales Paints

Two principal wastes result from the manufacture of solvent-thinned

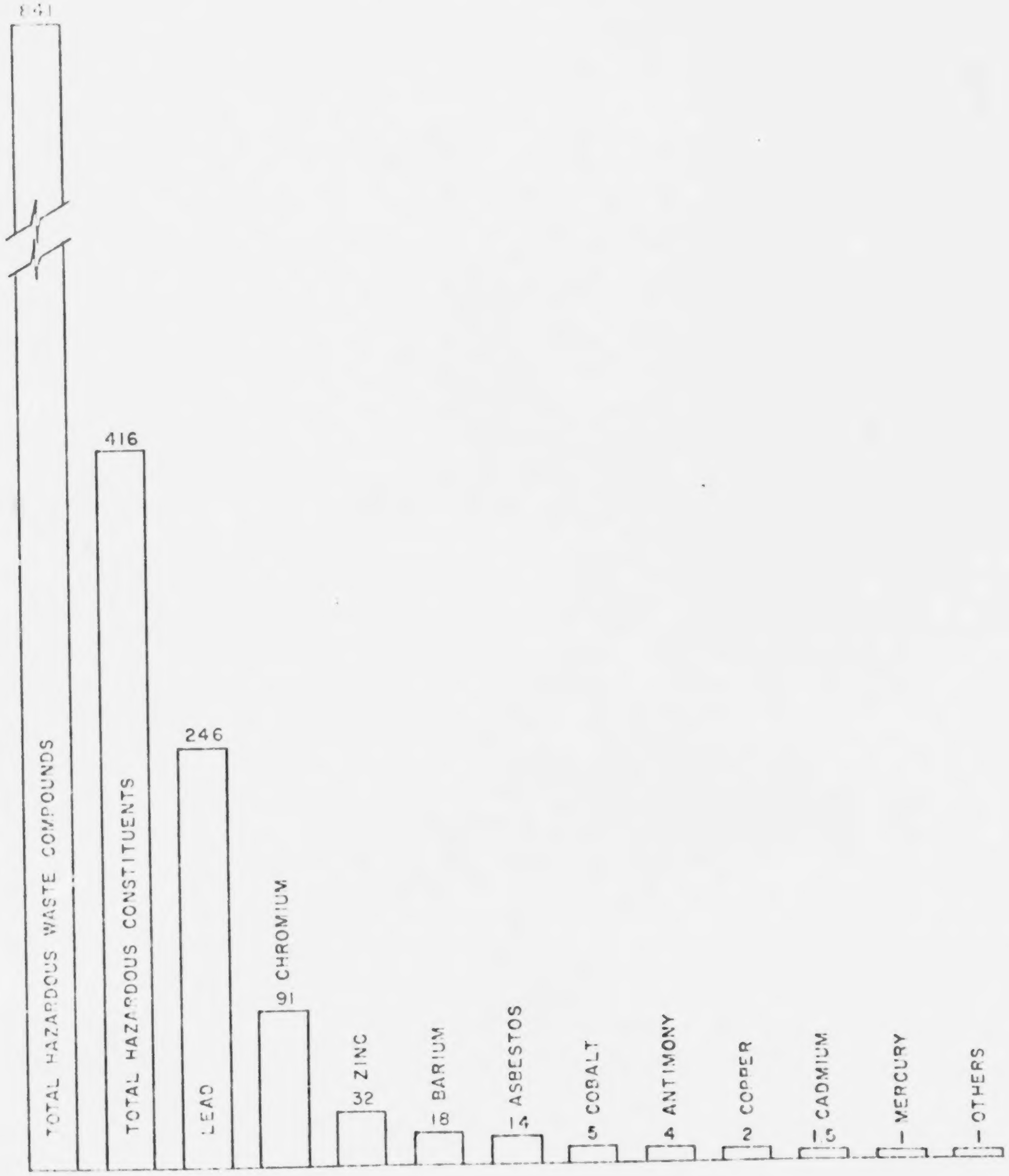


FIGURE 18

TOXIC CHEMICAL COMPOUNDS IN WASTE

(kkg/yr)

(WET WEIGHT)*

*Note: Wet Weight = Dry Weight

TABLE 22

QUANTITIES OF TOTAL PAINT
AND COATINGS INDUSTRY WASTES BY STATE - 1974
SIC 285
kkg/yr (tons/yr)
(Wet Weight)

STATES	EPA REGIONS	TOTAL WASTE METRIC TONS/YEAR		POTENTIALLY HAZARDOUS WASTE STREAM		HAZARDOUS SOLVENTS IN WASTE		TOXIC CHEMICAL COMPOUNDS IN WASTE	
AL, MS	IV	2,750	(3,025)	630	(750)	100	(110)	5.9	(6.5)
AK, OR	X	1,830	(2,013)	450	(500)	67	(74)	3.9	(4.3)
AZ	IX	480	(528)	120	(130)	18	(19)	1.0	(1.1)
AR, LA, OK	VI	3,200	(3,520)	790	(870)	117	(128)	6.9	(7.6)
CA	IX	51,000	(56,210)	12,600	(13,900)	1,375	(2,060)	111.4	(122.5)
CO	VIII	1,880	(2,068)	460	(510)	69	(76)	4.1	(4.5)
CT	I	940	(1,034)	230	(250)	35	(39)	2.0	(2.2)
DE,DC,WV,SC	III,IV	1,090	(1,199)	270	(300)	40	(44)	2.3	(2.5)
DC	III	See Delaware (See Note)							
FL	IV	6,380	(7,018)	1,540	(1,690)	232	(255)	13.7	(15.1)
GA	IV	14,370	(15,810)	3,540	(3,900)	565	(620)	31.0	(34.1)
HI	IX	No Paint Plants							
ID,MT,NV, NM,UT	X,VIII,IX, VI,VIII	1,220	(1,340)	300	(330)	50	(55)	2.6	(2.9)
IL	V	48,270	(53,100)	11,900	(13,100)	1,750	(1,925)	104.0	(114.4)
IN	V	5,970	(6,570)	1,470	(1,620)	275	(303)	12.9	(14.2)
IA	VII	5,510	(6,060)	1,360	(1,500)	200	(220)	11.9	(13.1)
KS,NB	VII	1,030	(1,130)	250	(270)	38	(42)	2.2	(2.4)
KY	IV	19,700	(21,670)	4,800	(5,340)	714	(785)	42.4	(46.6)
LA	VI	See Arkansas (See Note)							
ME,NH,VT	I	502	(550)	120	(130)	19	(21)	1.1	(1.2)
MD	III	8,750	(9,620)	2,160	(2,400)	317	(348)	18.8	(20.7)
MA	I	6,420	(7,070)	1,585	(1,740)	232	(255)	13.8	(15.2)
MI	V	23,190	(25,510)	5,720	(6,290)	840	(924)	49.9	(54.9)
MN	V	4,110	(4,520)	1,020	(1,120)	149	(164)	8.8	(9.7)
MS	IV	See Alabama (See Note)							
MO	VII	16,500	(18,150)	4,070	(4,480)	619	(681)	36.8	(40.5)
MT	VIII	See Idaho (See Note)							
NB	VII	See Kansas (See Note)							
NV	IX	See Idaho (See Note)							
NH	I	See Maine (See Note)							
NJ	II	39,490	(43,440)	9,750	(10,720)	1,432	(1,575)	85.1	(93.6)
NM	VI	See Idaho (See Note)							
NY	II	20,520	(22,570)	5,070	(5,580)	744	(818)	44.2	(48.6)
NC	IV	7,730	(8,500)	1,910	(2,100)	280	(308)	16.7	(18.4)
ND	VIII	No Paint Plants							
OH	V	36,380	(40,020)	8,980	(9,870)	1,320	(1,452)	78.4	(86.2)
OK	VI	See Arkansas (See Note)							
OR	X	See Alaska (See Note)							
PA	III	23,040	(25,340)	5,680	(6,250)	835	(919)	49.6	(54.6)
RI	I	680	(750)	160	(180)	24	(26)	1.5	(1.7)
SC	IV	See Delaware (See Note)							
SD	VIII	No Paint Plants							
TN	IV	3,000	(3,300)	740	(810)	109	(120)	6.5	(7.2)
TX	VI	21,330	(24,310)	5,390	(5,920)	792	(871)	47.0	(51.7)
UT	VIII	See Idaho (See Note)							
VT	I	See Maine (See Note)							
VA	III	3,350	(3,650)	830	(910)	120	(132)	7.2	(7.9)
WA	X	2,920	(3,210)	720	(790)	106	(116)	6.3	(6.9)
WV	III	See Delaware (See Note)							
WI	V	4,950	(5,440)	1,220	(1,340)	181	(199)	10.7	(11.8)
WY	VIII	No Paint Plants							
NATIONAL		388,992	(427,975)[1]	95,880[2]	(105,570)	14,264	(15,684)	840.6	(924.8)

NOTE: WITHHELD (BY CENSUS) TO AVOID DISCLOSING FIGURE FOR INDIVIDUAL COMPANIES.

[1] See Table 23.

[2] See Table 23.

TABLE 23

QUANTITIES OF TOTAL PAINT AND COATINGS INDUSTRY WASTES BY EPA REGION - 1974
SIC 285
kkg/yr (tons/yr)
(Wet Weight)

EPA Region	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
I	8,552(9,404)	2,090(2,300)	310(341)	18.4(20.3)
II	60,010(66,010)	14,820(16,300)	2,174(2,393)	129.3(142.2)
III	35,788(39,458)	8,833(9,739)	1,311(1,445)	77.3(85.2)
IV	54,071(59,615)	13,345(14,713)	1,981(2,184)	116.9(128.9)
V	122,870(135,160)	30,310(33,340)	4,515(4,967)	264.7(291.2)
VI	25,285(27,878)	6,242(6,882)	926(1,021)	54.6(60.2)
VII	23,040 25,348)	5,680(6,250)	857(943)	50.9(56.0)
VIII	2,334(2,573)	576(635)	85(94)	5.1(5.6)
IX	51,737(57,042)	12,769(14,078)	1,895(2,089)	111.8(123.3)
X	5,057(5,576)	1,248(1,376)	185(204)	10.9(12.0)
NATIONAL	388,744(428,056)[1]	95,913(105,613)[2]	14,241(15,681)	839.9(924.9)

---

[1] Contains approximately 5% water. [2] Contains approximately 22% water.

trade sales paints. One is the small amount of raw materials left in discarded paper bags and the other is solvents used for clean-up of manufacturing equipment. Only about five percent of the raw materials are purchased in sufficient quantities to justify bulk handling, a practice which would reduce this waste source. The amount of solvent can be controlled by careful housekeeping and scheduling of production. If the same product is being made repeatedly in the same batch equipment, little washing is necessary. In many cases, wash solvent may be incorporated in the formulation of a succeeding batch. Smaller plants, which must use the same equipment for a variety of products, may have more difficulty in controlling waste wash solvent.

Other wastes include batches which cannot be reworked into saleable products, spills which cannot be recovered, and residues from air pollution control equipment. The amount of these wastes is determined by the amount of care and attention devoted to housekeeping, production, and the quality of the products being manufactured, which determines whether spoiled batches or spills can be reworked profitably. In general, the amount of such wastes tends to be relatively small since large losses from any of these sources cannot be tolerated economically.

Table 24 illustrates the 1974 national distribution of wastes attendant to the production of solvent-thinned trade sales paints by waste stream.

The figures used in Table 24 and similar ones presented subsequently on other subcategories are necessarily estimates since the individual waste streams are not monitored. Data gathered from about 70 plants or 8.6 percent of the total paint production in the country provided the basis for this series of tables. National totals for each waste stream are estimated to be within ±40 percent. No breakdown of individual compounds by waste stream is given as no reasonable estimate can be made from the data available.

Similarly, insufficient data are available within the scope of this study to break down individual waste stream quantities by state. Extrapolations to each state on the basis of production were abandoned because the relevant data available is not sufficiently reliable.

Table 25, however, shows the estimated 1974 state distribution of solvent-thinned trades sales paint wastes according to waste characterization as opposed to waste source. This table and its counterparts in ensuing pages are also based on plant survey information which is shown in Appendix F. Table 26 shows the same breakdown by EPA region.

The 1974 quantities of toxic metallic elements in solvent-thinned trade sales paints are shown by state in Table 27.

Minor differences in comparable totals for Tables 24 through 27 are due to rounding off of individual state data.

TABLE 24

QUANTITIES OF WASTE STREAMS BY SOURCE - 1974
SOLVENT-THINNED TRADE SALES PAINTS
SIC 28511 & 28513
kkg/yr (tons/yr)
(Wet Weight)*

Waste Stream	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
Cleanings	19,600(21,610)	19,600(21,610)	4,350(4,796)	251(277)
Raw Material Packaging	69,920(76,912)	880(970)	---	55(61)
Air Pollution Collection	370(408)	370(408)	---	34(37)
Spoiled Batches	920(1,014)	920(1,014)	187(206)	18(20)
Spills	1,290(1,422)	1,290(1,422)	27(30)	2(2)
TOTAL	92,100(101,366)	23,060(25,424)	4,564(5,032)	360(397)

* Note: Wet Weight = Dry Weight

TABLE 25

QUANTITIES OF WASTES FROM MANUFACTURE OF SOLVENT-THINNED TRADE SALES PAINTS BY STATE - 1974
SIC 28511 & 28513
kkg/yr*
(Wet Weight)**

STATE	EPA REGION	TOTAL WASTE	POTENTIALLY HAZARDOUS WASTE STREAM	HAZARDOUS SOLVENTS IN WASTE	TOXIC CHEMICAL COMPOUNDS IN WASTE
AL,MS	IV	654	163	32	2.6
AK,OR	X	433	108	21	1.7
AZ	IX	111	28	5	.4
AR,LA,OK	VI	755	189	37	3.0
CA	IX	12074	3015	598	47.2
CO	VIII	442	110	22	1.7
CT	I	221	55	11	.9
DE,DC,WV,SC	III,IV	258	64	13	1.0
DC	III	SEE DELAWARE			
FL	IV	1474	368	73	5.8
GA	IV	3399	849	168	13.3
HI	IX	NO PAINT PLANTS			
ID,MT,NV	X,VIII,IX				
NM,UT	VI,VIII	286	71	14	1.1
IL	V	11420	2852	566	44.6
IN	V	1409	352	70	5.5
IA	VII	1308	327	65	5.1
KS,NB	VII	239	60	12	.9
KY	IV	4660	1164	231	18.2
LA	VI	SEE ARKANSAS			
ME,NH,VT	I	120	30	6	.5
MD	III	2072	518	103	8.1
MA	I	1520	380	75	5.9
MI	V	5489	1371	272	21.5
MN	V	976	244	48	3.8
MS	IV	SEE ALABAMA			
MO	VII	3905	975	194	15.3
MT	VIII	SEE IDAHO			
NB	VII	SEE KANSAS			
NV	IX	SEE IDAHO			
NH	I	SEE MAINE			
NJ	II	9348	2334	463	36.5
NM	VI	SEE IDAHO			
NY	II	4863	1214	241	19.0
NC	IV	1833	458	91	7.2
ND	VIII	NO PAINT PLANTS			
OH	V	8611	2151	427	33.7
OK	VI	SEE ARKANSAS			
OR	X	SEE ALASKA			
PA	III	5452	1362	270	21.3
RI	I	157	39	8	.6
SC	IV	SEE DELAWARE			
SD	VIII	NO PAINT PLANTS			
TN	IV	709	177	35	2.8
TX	VI	5167	1290	256	20.2
UT	VIII	SEE IDAHO			
VT	I	SEE MAINE			
VA	III	792	198	39	3.1
WA	X	691	173	34	2.7
WV	III	SEE DELAWARE			
WI	V	1170	292	58	4.6
WY	VIII	NO PAINT PLANTS			
NATIONAL		92017	22981	4558	359.8

---

* To convert data to tons/yr, multiply by 1.1.

** Note: Wet Weight = Dry Weight.

TABLE 26

QUANTITIES OF WASTES FROM MANUFACTURE OF SOLVENT-THINNED TRADE SALES PAINTS BY EPA REGION - 1974
SIC 28511 & 28513
kkg/yr (tons/yr)
(Wet Weight)*

EPA Region	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
I	2,018(2,220)	504(554)	100(110)	7.9(8.7)
II	14,211(15,632)	3,548(3,903)	704(774)	55.5(61.1)
III	8,473(9,342)	2,116(2,333)	420(463)	33.1(36.5)
IV	12,802(14,115)	3,197(3,525)	639(700)	50.0(55.1)
V	29,075(31,982)	7,262(7,988)	1,441(1,585)	113.7(125.1)
VI	5,987(6,601)	1,495(1,648)	297(327)	23.4(25.8)
VII	5,452(5,997)	1,362(1,498)	271(298)	21.2(23.4)
VIII	553(610)	138(152)	27(30)	2.2(2.4)
IX	12,249(13,505)	3,059(3,373)	607(669)	47.9(52.8)
X	1,197(1,320)	299(330)	59(65)	4.7(5.2)
NATIONAL	92,017(101,324)	22,980(25,304)	4,565(5,021)	359.7(306.2)

* Note: Wet Weight = Dry Weight

TABLE 27

QUANTITIES OF TOXIC METALLIC ELEMENTS
IN SOLVENT-THINNED TRADE SALES PAINT WASTES - 1974
SIC 28511 & 28513
kg/yr*
(Wet Weight) **

STATES	EPA REGIONS	LEAD	CHROMIUM	ZINC	BARIUM	COBALT	OTHERS
AL, MS	IV	0.8	0.3	0.1	0.06	0.02	0.03
AK, OR	X	0.5	0.2	0.07	0.04	0.01	0.02
AZ	IX	0.2	0.06	0.02	0.01		
AR, LA, OK	VI	1.0	0.4	0.1	0.07	0.02	0.03
CA	IX	15.4	5.8	1.9	1.1	0.3	0.5
CO	VIII	0.5	0.2	0.07	0.04	0.01	0.02
CT	I	0.3	0.1	0.04	0.02		0.01
DE,DC,WV,SC	III,IV	0.4	0.1	0.04	0.02		0.01
DC	III						
FL	IV	1.9	0.7	0.2	0.1	0.04	0.06
GA	IV	4.3	1.6	0.5	0.3	0.03	0.2
HI	IX						
ID,MT,NV, NM,UT	X,VIII,IX VI,VIII	0.4	0.1	0.05	0.03		0.01
IL	V	14.2	5.3	1.8	1.0	0.3	0.5
IN	V	1.8	0.1	0.2	0.1	0.03	0.06
IA	VII	1.6	0.6	0.2	0.1	0.03	0.05
KS,NB	VII	0.3	0.1	0.04	0.02		0.01
KY	IV	5.7	2.1	0.7	0.4	0.1	0.2
LA	VI						
ME,NH,VT	I	0.1	0.04	0.01			
MD	III	2.6	1.0	0.3	0.2	0.05	0.1
MA	I	1.9	0.7	0.2	0.1	0.04	0.07
MI	V	6.8	2.6	0.9	0.5	0.1	0.2
MN	V	1.2	0.5	0.2	0.08	0.02	0.04
MS	IV						
MO	VII	5.0	1.9	0.6	0.3	0.09	0.2
MT	VIII						
NB	VII						
NV	IX						
NH	I						
NJ	II	11.7	4.4	1.5	0.8	0.2	0.4
NM	VI						
NY	II	6.0	2.3	0.8	0.4	0.1	0.2
NC	IV	2.3	0.9	0.3	0.2	0.04	0.08
ND	VIII						
OH	V	10.8	4.0	1.3	0.7	0.2	0.4
OK	VI						
OR	X						
PA	III	6.8	2.6	0.9	0.5	0.1	0.3
RI	I	0.2	0.07	0.02	0.01		
SC	IV						
SD	VIII						
TN	IV	0.9	0.3	0.1	0.06	0.02	0.03
TX	VI	6.5	2.4	0.8	0.5	0.1	0.2
UT	VIII						
VT	I						
VA	III	1.0	0.4	0.1	0.07	0.02	0.03
WA	X	0.9	0.3	0.1	0.06	0.02	0.03
WV	III						
WI	V	1.5	0.6	0.2	0.1	0.03	0.05
WY	VIII						
NATIONAL		115.5	42.8	14.4	8.0	2.1	4.0

---

* To convert data to tons/yr, multiply by 0.0011.

** Note: Wet Weight = Dry Weight.

Water-Thinned Trade Sales Paints

The sources of wastes in the manufacture of water-thinned trade sales paints are essentially the same as those described under solvent-thinned trade sales paints -- i.e., raw materials packages and clean-up of mixers, mills, and tanks. The volume of the wastes is likely to be substantially larger than those from solvent-thinned paints because the mills and tanks are usually washed out with water, which can be used economically in large quantities. However, relatively large volumes facilitate the settling of the paint ingredients as a sludge from the water. The other principal differences in the character of the wastes are that those from water-thinned paints are less likely to contain lead compounds since they are rarely used in this type of coating, and it is also uncommon to find drier metals. Preservatives or bacteriacides are almost always used, and mercury-based compounds are the most common additives for this purpose, although they are used in very small concentrations. Similar compounds are used in solvent-thinned paints.

Table 28 illustrates the 1974 national distribution of wastes attendant to the production of water-thinned trade sales paints by waste source. Table 29 shows the estimated state distribution of the wastes of this subcategory according to their characteristics. These estimates were derived in the same manner as those for solvent-thinned products. Data used in the preparation of Table 29 are shown in Appendix E. Table 30 shows the characteristics distribution by EPA region.

The 1974 quantities of toxic metallic elements in water-thinned paints are shown by state in Table 31.

Minor differences in comparable totals for Tables 28-31 are due to rounding off of individual state data.

Industrial and Non-Industrial Lacquers

In general, wastes from the manufacture of lacquers follow the same pattern as those from solvent-thinned trade sales paints -- i.e., residue from the raw materials used and clean-up solvent from mills and tanks. The nature of the potentially hazardous wastes are similar, but the quantities of wastes are generally much smaller. Care is taken not to waste the more expensive raw materials and wash solvents which are used in lacquers such as methyl ethyl ketone, methyl isobutyl ketone, butyl alcohol and isopropyl alcohol.

Table 32 illustrates the 1974 national distribution of wastes attendant to the production of industrial and non-industrial lacquers by waste source. Table 33 shows the estimated state distribution of the wastes of this subcategory according to their characteristics and Table 34 shows totals by EPA region. See Appendix E for data used to derive this information. The 1974 quantities of toxic metallic elements

TABLE 28

QUANTITIES OF WASTE STREAMS BY SOURCE - 1974
WATER-THINNED TRADE SALES PAINTS
SIC 28512 & 28514
kkg/yr (tons/yr)
(Wet Weight)

Waste Stream	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
Cleanings	24,500(27,012)[1]	24,500(27,012)[1]	------	36 (40)
Raw Material Packaging	87,160(96,097)	120(132)	------	8 (9)
Air Pollution Collection	460(507)	460(507)	------	5 (6)
Spoiled Batches	1,150(1,268)[2]	1,150(1,268)[2]	------	2 (2)
Spills	1,610(1,775)[2]	1,610(1,775)[2]	------	0.5(0.6)
TOTAL	114,880(126,659)[2]	27,840(30,694)[3]	------	51.5(56.6)

---

[1] Contains 85% water.

[2] Contains approximately 20% water.

[3] Contains approximately 70% water.

TABLE 29

QUANTITIES OF WASTES FROM MANUFACTURE OF
WATER-THINNED TRADE SALES PAINTS BY STATE - 1974
SIC 28512 & 28514
kkg/yr*
(Wet Weight)

STATE	EPA REGION	TOTAL WASTE	POTENTIALLY HAZARDOUS WASTE STREAM	HAZARDOUS SOLVENTS IN WASTE	TOXIC CHEMICAL COMPOUNDS IN WASTE
AL,MS	IV	816	198	------.	.4
AK,OR	X	540	131	------.	.2
AZ	IX	138	33	------.	.1
AR,LA,OK	VI	942	228	------.	.4
CA	IX	15061	3650	------.	6.8
CO	VIII	551	134	------.	.2
CT	I	276	67	------.	.1
DE,DC,WV,SC	III,IV	322	78	------.	.1
DC	III	SEE DELAWARE			
FL	IV	1839	445	------.	.8
GA	IV	4239	1027	------.	1.9
HI	IX	NO PAINT PLANTS			
ID,MT,NV	X,VIII,IX			------.	
NM,UT	VI,VIII	356	86	------.	.2
IL	V	14245	3452	------.	6.4
IN	V	1758	426	------.	.8
IA	VII	1631	395	------.	.7
KS,NB	VII	299	72	------.	.1
KY	IV	5813	1409	------.	2.6
LA	VI	SEE ARKANSAS			
ME,NH,VT	I	149	36	------.	.1
MD	III	2585	626	------.	1.2
MA	I	1896	459	------.	.8
MI	V	6847	1659	------.	3.1
MN	V	1218	295	------.	.5
MS	IV	SEE ALABAMA			
MO	VII	4871	1180	------.	2.2
MT	VIII	SEE IDAHO			
NB	VII	SEE KANSAS			
NV	IX	SEE IDAHO			
NH	I	SEE MAINE			
NJ	II	11660	2826	------.	5.2
NM	VI	SEE IDAHO			
NY	II	6066	1470	------.	2.7
NC	IV	2285	554	------.	1.0
ND	VIII	NO PAINT PLANTS			
OH	V	10741	2603	------.	4.8
OK	VI	SEE ARKANSAS			
OR	X	SEE ALASKA			
PA	III	6801	1648	------.	3.0
RI	I	195	47	------.	.1
SC	IV	SEE DELAWARE			
SD	VIII	NO PAINT PLANTS			
TN	IV	885	214	------.	.4
TX	VI	6445	1562	------.	2.9
UT	VIII	SEE IDAHO			
VT	I	SEE MAINE			
VA	III	988	239	------.	.4
WA	X	862	209	------.	.4
WV	III	SEE DELAWARE			
WI	V	1459	354	------.	.7
WY	VIII	NO PAINT PLANTS			
NATIONAL		150,779[1]	27312[2]		51.3

---

[1] Contains approximately 20% water. [2] Contains approximately 75% water.

*To convert data to tons/yr, multiply by 1.1.

TABLE 30

QUANTITIES OF WASTES FROM MANUFACTURE OF WATER-THINNED TRADE SALES PAINTS BY EPA REGION - 1974
SIC 28512 & 28514
kkg/yr (tons/yr)
(Wet Weight)

EPA Region	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
I	2,516(2,768)	609(670)	------	1.1(1.2)
II	17,726(19,499)	4,2 (4,72)	------	7.9(8.7)
III	10,569(11,653)	2,561(2,824)	------	4.7(5.2)
IV	15,968(17,605)	3,870(4,267)	------	7.2(7.9)
V	36,268(39,895)	8,789(9,668)	------	16.3(18.0)
VI	7,467(8,233)	1,810(1,996)	------	3.3(3.6)
VII	6,801(7,481)	1,647(1,812)	------	3.0(3.3)
VIII	689(760)	167(184)	------	0.3(0.3)
IX	15,280(16,847)	3,703(4,083)	------	6.9(7.6)
X	1,493(1,646)	362(399)	------	0.7(0.8)
NATIONAL	114,777(126,387)[1]	27,840(30,629)[2]	------	51.4(56.6)

---

[1] Contains approximately 20% water. [2] Contains approximately 75% water.

TABLE 31

QUANTITIES OF TOXIC METALLIC ELEMENTS
IN WATER-THINNED TRADE SALES PAINT WASTES - 1974
SIC 28512 & 28514
kg/yr*
(Wet Weight)**

STATES	EPA REGIONS	KILOGRAMS			
		BARIUM	COPPER	CADMIUM	MERCURY
AL, MS	IV	44			
AK, OR	X	30			
AZ	IX	9			
AR, LA, OK	VI	51			
CA	IX	830	75	75	75
CO	VIII	30			
CT	I	15			
DE,DC,WV,SC	III,IV	19			
DC	III				
FL	IV	90			
GA	IV	230	20	20	20
HI	IX				
ID,MT,NV, NM,UT	X,VIII,IX VI,VIII	22			
IL	V	770	70	70	70
IN	V	95			
IA	VII	88			
KS,NB	VII	17			
KY	IV	315	30	30	30
LA	VI				
ME,NH,VT	I	8			
MD	III	140	10	10	10
MA	I	10			
MI	V	370	30	30	30
MN	V	65			
MS	IV				
MO	VII	270	25	25	25
MT	VIII				
NB	VII				
NV	IX				
NH	I				
NJ	II	630	60	60	60
NM	VI				
NY	II	330	30	30	30
NC	IV	125	10	10	10
ND	VIII				
OH	V	580	50	50	50
OK	VI				
OR	X				
PA	III	370	35	35	35
RI	I	11			
SC	IV				
SD	VIII				
TN	IV	48			
TX	VI	350	30	30	30
UT	VIII				
VT	I				
VA	III	54			
WA	X	46			
WV	III				
WI	V	80			
WY	VIII				
NATIONAL		5942	475	475	475

---

* To convert data to tons/yr, multiply by 0.0011

** Note: Wet Weight = Dry Weight

TABLE 32

QUANTITIES OF WASTE STREAMS BY SOURCE - 1974
INDUSTRIAL AND NON-INDUSTRIAL LACQUERS
SIC 28515 & 28517
kkg/yr (tons/yr)
(Wet Weight)*

Waste Stream	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
Cleanings	5,590(6,163)	5,590(6,163)	2,540(2,800)	5.8(6.3)
Raw Material Packaging	19,910(21,951)	21(23)	---	1.3(1.4)
Air Pollution Collection	105(116)	105(116)	---	0.8(0.9)
Spoiled Batches	260(287)	260(287)	112(123)	0.4(0.4)
Spills	365(402)	365(402)	16(18)	0.06(0.07)
TOTAL	26,230(28,919)	6,341(6,991)	2,668(2,941)	8.4(9.1)

*Note: Wet Weight = Dry Weight

TABLE 33

QUANTITIES OF WASTES FROM MANUFACTURE OF INDUSTRIAL AND NON-INDUSTRIAL LACQUERS BY STATE - 1974
SIC 28515 & 28517
kkg/yr*
(Wet Weight)**

STATE	EPA REGION	TOTAL WASTE	POTENTIALLY HAZARDOUS WASTE STREAM	HAZARDOUS SOLVENTS IN WASTE	TOXIC CHEMICAL COMPOUNDS IN WASTE
AL,MS	IV	186	45	19	.1
AK,OR	X	123	30	13	0
AZ	IX	31	8	3	0
AR,LA,OK	VI	215	52	22	.1
CA	IX	3439	831	350	1.1
CO	VIII	126	30	13	0
CT	I	63	15	6	0
DE,DC,WV,SC	III,IV	73	18	7	0
DC	III	SEE DELAWARE			
FL	IV	420	101	43	.1
GA	IV	968	234	99	.3
HI	IX	NO PAINT PLANTS			
ID,MT,NV NM,UT	X,VIII,IX VI,VIII	81	20	8	0
IL	V	3253	786	331	1.0
IN	V	401	97	41	.1
IA	VII	372	90	38	.1
KS,NB	VII	68	16	7	0
KY	IV	1327	321	135	.4
LA	VI	SEE ARKANSAS			
ME,NH,VT	I	34	8	3	0
MD	III	590	143	60	.2
MA	I	433	135	44	.1
MI	V	1563	378	159	.5
MN	V	278	67	28	.1
MS	IV	SEE ALABAMA			
MO	VII	1112	269	113	.4
MT	VIII	SEE IDAHO			
NB	VII	SEE KANSAS			
NV	IX	SEE IDAHO			
NH	I	SEE MAINE			
NJ	II	2662	644	271	.8
NM	VI	SEE IDAHO			
NY	II	1385	335	141	.4
NC	IV	522	126	53	.2
ND	VIII	NO PAINT PLANTS			
OH	V	2453	593	250	.8
OK	VI	SEE ARKANSAS			
OR	X	SEE ALASKA			
PA	III	1553	375	158	.5
RI	I	45	11	5	0
SC	IV	SEE DELAWARE			
SD	VIII	NO PAINT PLANTS			
TN	IV	202	49	21	.1
TX	VI	1472	356	150	.5
UT	VIII	SEE IDAHO			
VT	I	SEE MAINE			
VA	III	226	55	23	.1
WA	X	197	48	20	.1
WV	III	SEE DELAWARE			
WI	V	333	81	34	.1
WY	VIII	NO PAINT PLANTS			
NATIONAL		26,206	6,337	2,668	8.2

---

* To convert data to tons/yr, multiply by 1.1.

** Note: Wet Weight = Dry Weight

TABLE 34

QUANTITIES OF WASTES FROM MANUFACTURE OF INDUSTRIAL AND NON-INDUSTRIAL LACQUERS BY EPA REGION - 1974
SIC 28515 & 28517
kkg/yr (tons/yr)
(Wet Weight) *

EPA Region	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
I	575(632)	139(153)	58(64)	0.1(0.1)
II	4,047(4,452)	979(1,077)	412(453)	1.2(1.3)
III	2,413(2,660)	583(643)	246(271)	0.8(0.9)
IV	3,646(4,020)	881(971)	371(409)	1.2(1.3)
V	8,281(9,100)	2,002(2,202)	843(927)	2.6(2.9)
VI	1,705(1,880)	412(454)	174(192)	0.5(0.6)
VII	1,552(1,707)	375(412)	158(174)	0.5(0.6)
VIII	157(173)	38(42)	16(18)	0.1(0.1)
IX	3,489(3,847)	843(929)	355(391)	1.1(1.2)
X	341(376)	83(92)	35(39)	0.1(0.1)
NATIONAL	26,206(28,856)	6,335(6,975)	2,668(2,938)	8.2(9.1)

*Note: Wet Weight = Dry Weight

in lacquers are shown by state in Table 35. Where quantities are estimated to be less than 10 kg (11 lb) they have not been included because of the inaccuracy of the extrapolation to such small quantities.

Factory-Applied Coatings

Table 37, which shows the quantities of wastes attendant to the manufacture of industrial coatings nationally and by state, bears out the fact that the toxic chemical content of these products is similar to that of solvent-thinned coatings. As discussed earlier, the formulations of factory-applied coatings are usually quite similar to trade sales solvent-thinned coatings. These estimates were derived in the manner described earlier for similar tables; additional data is shown in Appendix F. Totals by EPA region are shown in Table 39.

Table 36 illustrates the national distribution of this subcategory's wastes by waste stream. It will be noted that the quantity of spoiled (or rejected) batches produced by the manufacture of factory-applied coatings may be somewhat greater than is the case with the production of other coatings since, in general, the quality control of industrial paints is higher, and the opportunity to work off batches that do not meet the standard is lower -- particularly in color, which is the prime cause of rejection of industrial batches. Also, since industrial batches often are larger than trade sales, it is more difficult to work off a whole batch.

The 1974 quantities of toxic metallic elements in factory-applied coatings wastes are shown by state in Table 39.

Putty and Miscellaneous Products

There are few potentially hazardous wastes associated with the manufacture of putty. First, since the material is handled in the form of a stiff paste, there is little spillage or other accidental loss. Any that occurs can be gathered up easily and re-incorporated in the process. Further, since putty does not require either specific color or fineness of grind, stray particles of dirt, etc., do not cause any problem. The manufacture of putty rarely requires any equipment cleaning since, in general, the mixers are used only for the one product and any material left from one batch can be incorporated in the succeeding one. Any unusable material which is discarded contains no hazardous ingredients.

Table 40 illustrates the 1974 national distribution of wastes attendant to the production of putty and miscellaneous paint products by waste source. The columns tabulating cleanings, air pollution collection, spoiled batches, and spills apply to the production of miscellaneous products since there are essentially no wastes of these types

TABLE 35

QUANTITIES OF TOXIC METALLIC ELEMENTS IN INDUSTRIAL & NON-INDUSTRIAL LACQUER WASTES - 1974

SIC 28515 & 28517
kg/yr*
(Wet Weight)**

STATES	EPA REGIONS	KILOGRAMS				
		COPPER	CADMIUM	LEAD	CHROMIUM	OTHER
AL, MS	IV					
AK, OR	X					
AZ	IX					
AR, LA, OK	VI					
CA	IX	25	50	120	50	50
CO	VIII					
CT	I					
DE,DC,WV,SC	III,IV					
DC	III					
FL	IV			15		
GA	IV		10	30	10	10
HI	IX					
ID,MT,NV, NM,UT	X,VIII,IX VI,VIII					
IL	V	20	45	100	45	45
IN	V			10		
IA	VII			10		
KS,NB	VII					
KY	IV	10	20	50	20	20
LA	VI					
ME,NH,VT	I					
MD	III			20		
MA	I			15		
MI	V	10	20	50	20	20
MN	V			10		
MS	IV					
MO	VII		20	40	20	20
MT	VIII					
NB	VII					
NV	IX					
NH	I					
NJ	II	20	40	90	40	40
NM	VI					
NY	II	10	20	50	20	20
NC	IV			20		
ND	VIII					
OH	V	20	30	90	30	30
OK	VI					
OR	X					
PA	III	10	20	50	20	20
RI	I					
SC	IV					
SD	VIII					
TN	IV					
TX	VI	10	20	50	20	20
UT	VIII					
VT	I					
VA	III			10		
WA	X					
WV	III					
WI	V			10		
WY	VIII					
	NATIONAL	135	295	840	295	295

---

* To convert data to tons/yr, multiply by 0.0011.

** Note: Wet Weight = Dry Weight

TABLE 36

QUANTITIES OF WASTE STREAMS BY SOURCE - 1974
FACTORY-APPLIED COATINGS
SIC 28516
kkg/yr (tons /yr)
(Wet Weight)*

Waste Stream	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
Cleanings	23,400(25,799)	23,400(25,799)	5,280(5,821)	239(264)
Raw Material Packaging	87,100(96,031)	830(915)	----	52(57)
Air Pollution Collection	460(507)	460(507)	----	33(36)
Spoiled Batches	2,150(2,370)	2,150(2,370)	222(245)	17(19)
Spills	1,610(1,775)	1,610(1,775)	32(35)	2(2)
TOTAL	114,720(126,482)	28,450(31,366)	5,534(6,101)	343(378)

*Note: Wet Weight = Dry Weight

TABLE 37

QUANTITIES OF WASTES FROM MANUFACTURE OF
FACTORY-APPLIED COATINGS BY STATE - 1974
SIC 28516
kkg/yr*
(Wet Weight)**

STATE	EPA REGION	TOTAL WASTE	POTENTIALLY HAZARDOUS WASTE STREAM	HAZARDOUS SOLVENTS IN WASTE	TOXIC CHEMICAL COMPOUNDS IN WASTE
AL,MS	IV	815	202	39	2.4
AK,OR	X	539	134	26	1.6
AZ	IX	138	34	7	.4
AR,LA,OK	VI	941	233	45	2.8
CA	IX	15040	3730	726	45.0
CO	VIII	551	137	27	1.6
CT	I	275	68	13	.8
DE,DC,WV,SC	III,IV	321	80	16	1.0
DC	III	SEE DELAWARE			
FL	IV	1836	455	89	5.5
GA	IV	4233	1050	204	12.7
HI	IX	NO PAINT PLANTS			
ID,MT,NV NM,UT	X,VIII,IX VI,VIII	356	88	17	1.1
IL	V	14225	3528	686	42.5
IN	V	1755	435	85	5.2
IA	VII	1629	404	79	4.9
KS,NB	VII	298	74	14	.9
KY	IV	5805	1440	280	17.4
LA	VI	SEE ARKANSAS			
ME,NH,VT	I	149	37	7	.4
MD	III	2581	640	125	7.7
MA	I	1893	469	91	5.7
MI	V	6937	1696	330	20.4
MN	V	1216	302	59	3.6
MS	IV	SEE ALABAMA			
MO	VII	4864	1206	235	14.5
MT	VIII	SEE IDAHO			
NB	VII	SEE KANSAS			
NV	IX	SEE IDAHO			
NH	I	SEE MAINE			
NJ	II	11644	2888	562	34.8
NM	VI	SEE IDAHO			
NY	II	6057	1502	292	18.1
NC	IV	2283	566	110	6.8
ND	VIII	NO PAINT PLANTS			
OH	V	10726	2660	518	32.1
OK	VI	SEE ARKANSAS			
OR	X	SEE ALASKA			
PA	III	6791	1684	328	20.3
RI	I	195	48	9	.6
SC	IV	SEE DELAWARE			
SD	VIII	NO PAINT PLANTS			
TN	IV	883	219	43	2.6
TX	VI	6436	1596	311	19.2
UT	VIII	SEE IDAHO			
VT	I	SEE MAINE			
VA	III	987	245	48	2.9
WA	X	860	213	42	2.6
WV	III	SEE DELAWARE			
WI	V	1457	361	70	4.4
WY	VIII	NO PAINT PLANTS			
NATIONAL		114,616	28,424	5550	342.5

---

* To convert data to tons/yr, multiply by 1.1.

** Note: Wet Weight = Dry Weight

TABLE 38

QUANTITIES OF WASTES FROM MANUFACTURE OF FACTORY-APPLIED COATINGS BY EPA REGION - 1974

SIC 28516
kkg/yr (tons/yr)
(Wet Weight)*

EPA Region	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
I	2,512(2,763)	622(684)	120(132)	7.5(8.3)
II	17,701(19,471)	4,390(4,829)	854(939)	52.9(58.2)
III	10,554(11,636)	2,617(2,885)	509(561)	31.5(34.7)
IV	15,946(17,581)	3,955(4,361)	769(848)	47.7(52.6)
V	36,216(39,838)	9,019(9,944)	1,755(1,935)	108.7(119.8)
VI	7,457(8,222)	1,849(2,039)	360(397)	22.3(24.6)
VII	6,791(7,470)	1,684(1,850)	328(361)	20.3(22.3)
VIII	688(759)	171(189)	33(36)	2.2(2.4)
IX	15,258(16,822)	3,784(4,172)	736(811)	45.6(50.3)
X	1,491(1,644)	370(408)	72(79)	4.5(5.0)
NATIONAL	114,614(126,206)	28,461(31,363)	5,536(6,099)	343.2(378.0)

*Note: Wet Weight = Dry Weight

TABLE 39

QUANTITIES OF TOXIC METALLIC ELEMENTS IN FACTORY-APPLIED COATING WASTES - 1974
SIC 28516
kg/yr*
(Wet Weight)**

STATES	EPA REGIONS	LEAD	CHROMIUM	ZINC	BARIUM	COBALT	OTHERS
AL, MS	IV	0.8	0.3	0.1	.05	.01	.03
AK, OR	X	0.5	0.2	0.06	.04	.01	.02
AZ	IX	0.2	0.06	0.02	.01		.01
AR, LA, OK	VI	0.9	0.3	0.1	.06	.02	.03
CA	IX	14.6	5.5	1.8	1.0	.3	.5
CO	VIII	0.5	0.2	0.07	.04	.01	.02
CT	I	0.3	0.1	0.03	.02		.01
DE,DC,WV,SC	III,IV	0.4	0.1	0.04	.02	.01	.01
DC	III						
FL	IV	1.8	0.7	0.2	.1	.03	.06
GA	IV	4.1	1.5	0.5	.3	.08	.1
HI	IX						
ID,MT,NV, NM,UT	X,VIII,IX VI,VIII	0.4	0.1	0.05	.03	.01	.01
IL	V	13.5	5.1	1.7	.9	.25	.5
IN	V	1.7	0.6	0.2	.1	.03	.06
IA	VII	1.5	0.6	0.2	.1	.03	.05
KS,NB	VII	0.3	0.1	0.04	.02	.01	.01
KY	IV	5.6	2.1	0.7	.4	.1	.2
LA	VI						
ME,NH,VT	I	0.1	0.05	0.02	.01		
MD	III	2.5	0.9	0.3	.2	.05	.09
MA	I	1.8	0.7	0.2	.1	.03	.06
MI	V	6.5	2.4	0.8	.4	.1	.2
MN	V	1.2	0.4	0.1	.08	.02	.04
MS	IV						
MO	VII	4.8	1.8	0.6	.3	.09	.2
MT	VIII						
NB	VII						
NV	IX						
NH	I						
NJ	II	11.1	4.2	1.4	.7	.2	.4
NM	VI						
NY	II	5.8	2.2	0.7	.4	.1	.2
NC	IV	2.2	0.8	0.3	.2	.04	.08
ND	VIII						
OH	V	10.2	3.8	1.3	.7	.2	.4
OK	VI						
OR	X						
PA	III	6.5	2.4	0.8	.4	.1	.2
RI	I	0.2	0.07	0.02	.01		.01
SC	IV						
SD	VIII						
TN	IV	0.8	0.3	0.1	.06	.02	.03
TX	VI	6.1	2.3	0.8	.4	.1	.2
UT	VIII						
VT	I						
VA	III	1.0	0.4	0.1	.07	.02	.03
WA	X	0.8	0.3	0.1	.06	.01	.03
WV	III						
WI	V	1.4	0.5	0.2	.09	.03	.05
WY	VIII						
	NATIONAL	110.1	41.1	13.6	7.4	2.0	3.8

---

* To convert data to tons/yr, multiply by 0.0011.

** Note: Wet Weight = Dry Weight

TABLE 40

QUANTITIES OF WASTE STREAMS BY SOURCE - 1974
PUTTY AND MISCELLANEOUS PAINT PRODUCTS
SIC 28518 & 28519
kkg/yr (tons/yr)
(Wet Weight)*

Waste Stream	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
Cleanings	8,680(9,570)	8,680(9,570)	1,410(1,555)	54(60)
Raw Material Packaging	30,910(34,079)	190(209)	---	12(13)
Air Pollution Collection	160(176)	160(176)	---	7(8)
Spoiled Batches	410(452)	410(452)	60(66)	4(4)
Spills	570(628)	570(628)	10(11)	0.5(0.6)
TOTAL	40,730(44,905)	10,010(11,035)	1,480(1,632)	77.5(85.6)

*Note: Wet Weight = Dry Weight

in putty manufacture. Table 41 shows the estimated state distribution of the wastes of this subcategory according to their characteristics and this distribution by EPA region is presented in Table 42. (See Appendix F.)

Projected Growth in Production and Wastes

According to the Bureau of the Census, the paint and coatings industry has been growing in recent years at an average rate of 4.6 percent per year. This growth rate has been used to project the production of this industry to 1977 and 1983 which is estimated at 4156 million liters (1098 million gal.) and 5318 million liters (1405 million gal.) respectively. The national waste totals for these years shown in Tables 43 and 44 were derived by extrapolating 1974 data shown in Table 22 up to the increased production. Totals by EPA region are shown in Table 45.

State totals in Tables 43 and 44 reflect the fact that growth rates vary considerably in different parts of the country and from state to state. For example, the rate is almost zero in New England and up to eight percent per year in some southern states. Thus, state totals in these tables are proportionate to their share of total growth rather than total projected production.

There is also a range of growth among different products. The most recently available Census data (1967-1972) which was used in extrapolation of growth rates by SIC subcategory is as follows:

SIC Code 28511 and 28513 - growth of interior and exterior solvent-thinned trade sales paints, 4.1%/yr.

SIC Code 28512 and 28514 - growth of interior and exterior water-thinned trade sales paints, 8.1%/yr.

SIC Code 28515 and 28517 - growth of industrial/non-industrial lacquers, 5.0%/yr.

SIC Code 28516 - growth of factory applied coatings, 2.7%/yr.

SIC Code 28518 and 28519 - growth of putty and miscellaneous paint products, 6.3%/yr.

Growth in production of specific products is discussed in more detail under the various industry subcategories.

In calculating wastes on direct relationship to production in Tables 43 and 44 it must be remembered that the proportional use of some of the potentially hazardous materials may be affected by government regulation, the direction of which is unclear at this time, and, in view of the present economic recession, the pace of growth may slacken which

TABLE 41

QUANTITIES OF WASTES FROM
MANUFACTURE OF PUTTY AND MISCELLANEOUS PAINT PRODUCTS BY STATE - 1974
SIC 28518 & 28519
kkg/yr*
(Wet Weight)**

STATE	EPA REGION	TOTAL WASTE	POTENTIALLY HAZARDOUS WASTE STREAM	HAZARDOUS SOLVENTS IN WASTE	TOXIC CHEMICAL COMPOUNDS IN WASTE
AL,MS	IV	289	71	11	.6
AK,OR	X	191	47	7	.4
AZ	IX	49	12	2	.1
AR,LA,OK	VI	334	82	12	.6
CA	IX	5340	1312	194	10.2
CO	VIII	196	48	7	.4
CT	I	98	24	4	.2
DE,DC,WV,SC	III,IV	114	28	4	.2
DC	III	SEE DELAWARE			
FL	IV	652	160	24	1.2
GA	IV	1503	369	55	2.9
HI	IX	NO PAINT PLANTS			
ID,MT,NV NM,UT	X,VIII,IX VI,VIII	120	31	5	.2
IL	V	5051	1241	184	9.6
IN	V	623	153	23	1.2
IA	VII	578	142	21	1.1
KS,NB	VII	106	26	4	.2
KY	IV	2061	507	75	3.9
LA	VI	SEE ARKANSAS			
ME,NH,VT	I	53	13	2	.1
MD	III	916	225	33	1.7
MA	I	672	165	24	1.3
MI	V	2428	597	88	4.6
MN	V	432	106	16	.8
MS	IV	SEE ALABAMA			
MO	VII	1727	424	63	3.3
MT	VIII	SEE IDAHO			
NB	VII	SEE KANSAS			
NV	IX	SEE IDAHO			
NH	I	SEE MAINE			
NJ	II	4134	1016	150	7.9
NM	VI	SEE IDAHO			
NY	II	2151	529	78	4.1
NC	IV	811	199	29	1.5
ND	VIII	NO PAINT PLANTS			
OH	V	3808	936	138	7.2
OK	VI	SEE ARKANSAS			
OR	X	SEE ALASKA			
PA	III	2411	593	88	4.6
RI	I	69	17	3	.1
SC	IV	SEE DELAWARE			
SD	VIII	NO PAINT PLANTS			
TN	IV	314	77	11	.6
TX	VI	2285	562	83	4.3
UT	VIII	SEE IDAHO			
VT	I	SEE MAINE			
VA	III	350	86	13	.7
WA	X	305	75	11	.6
WV	III	SEE DELAWARE			
WI	V	517	127	19	1.0
WY	VIII	NO PAINT PLANTS			
NATIONAL		40730	10010	1480	77.5

---

* To convert data to tons/yr, multiply by 1.1.

** Note: Wet Weight = Dry Weight

TABLE 42

QUANTITIES OF WASTES FROM MANUFACTURE OF PUTTY AND MISCELLANEOUS PAINT PRODUCTS BY EPA REGION - 1974
SIC 28518 & 28519
kkg/yr (tons/yr)
(Wet Weight)*

EPA Region	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
I	892(981)	219(241)	33(36)	1.7(1.9)
II	6,285(6,914)	1,545(1,700)	228(251)	12.0(13.1)
III	3,747(4,131)	921(1,015)	136(150)	7.1(7.8)
IV	5,662(6,243)	1,391(1,534)	206(227)	10.8(11.9)
V	12,859(14,145)	3,160(3,476)	468(515)	24.4(26.8)
VI	2,648(2,920)	651(718)	96(106)	5.0(5.5)
VII	2,411(2,652)	59 (652)	88(97)	4.6(5.1)
VIII	244(269)	60(66)	9(10)	0.5(0.6)
IX	5,417(5,972)	1,331(1,467)	197(217)	10.3(11.4)
X	530(584)	130(143)	19(21)	1.0(1.1)
NATIONAL	40,695(44,811)	10,000(11,010)	1,480(1,631)	77.4(85.2)

*Note: Wet Weight = Dry Weight

TABLE 43

QUANTITIES OF TOTAL PAINT & COATINGS INDUSTRY WASTES BY STATE - 1977
SIC 285
kkg/yr (tons/yr)
(Wet Weight)

STATES	EPA REGIONS	TOTAL WASTE METRIC	TONS/YEAR	POTENTIALLY HAZARDOUS WASTE STREAM		HAZARDOUS SOLVENTS IN WASTE		TOXIC CHEMICAL COMPOUNDS IN WASTE	
AL, MS	IV	3,700	(4,070)	910	(1,000)	117	(128)	7.7	(8.4)
AK, OR	X	2,190	(2,410)	540	(600)	72	(80)	4.5	(5.0)
AZ	IX	630	(700)	160	(170)	19	(21)	1.3	(1.4)
AR, LA, OK	VI	3,610	(3,970)	890	(980)	122	(134)	7.5	(8.3)
CA	IX	61,120	(67,230)	15,100	(16,600)	2,030	(2,230)	128.6	(141.5)
CO	VIII	2,490	(2,730)	610	(670)	77	(84)	5.2	(5.8)
CT	I	980	(1,080)	240	(270)	37	(40)	2.0	(2.2)
DE,DC,WV,SC	III,IV	1,190	(1,310)	290	(320)	40	(49)	2.4	.(2.7)
DC	III	See Delaware (See Note)							
FL	IV	8,360	(9,200)	2,070	(2,270)	260	(285)	17.3	(19.1)
GA	IV	18,840	(20,720)	4,660	(5,120)	640	(700)	39.2	(43.2)
HI	IX	No Paint Plants							
ID,MT,NV, NM,UT	X,VIII,IX VI,VIII	1,460	(1,610)	360	(390)	54	(60)	3.0	(3.3)
IL	V	51,620	(56,790)	12,700	(14,000)	1,790	(1,970)	107.3	(118.1)
IN	V	6,390	(7,030)	1,580	(1,740)	280	(308)	13.3	(14.6)
IA	VII	6,590	(7,250)	1,620	(1,780)	218	(240)	13.7	(15.1)
KS,NB	VII	1,230	(1,360)	300	(330)	38	(42)	2.5	(2.8)
KY	IV	27,190	(29,900)	6,700	(7,400)	840	(925)	56.5	(62.1)
LA	VI	See Arkansas (See Note)							
ME,NH,VT	I	520	(580)	130	(150)	21	(23)	1.1	(1.2)
MD	III	11,470	(12,620)	2,830	(3,120)	362	(398)	23.8	(26.2)
MA	I	6,730	(7,400)	1,670	(1,830)	234	(257)	13.9	(15.3)
MI	V	26,670	(29,340)	6,600	(7,200)	860	(940)	51.5	(56.7)
MN	V	4,920	(5,410)	1,210	(1,330)	160	(178)	10.2	(11.2)
MS	IV	See Alabama (See Note)							
MO	VII	19,730	(21,710)	4,870	(5,350)	670	(740)	42.5	(46.7)
MT	VIII	See Idaho (See Note)							
NB	VII	See Kansas (See Note)							
NV	IX	See Idaho (See Note)							
NH	I	See Maine (See Note)							
NJ	II	43,140	(47,460)	10,700	(11,700)	1,480	(1,620)	89.7	(98.7)
NM	VI	See Idaho (See Note)							
NY	II	22,420	(24,660)	5,500	(6,100)	770	(850)	46.6	(51.3)
NC	IV	10,130	(11,150)	2,500	(2,750)	320	(350)	21.1	(23.2)
ND	VIII	No Paint Plants							
OH	V	38,910	(42,800	9,600	(10,600)	1,340	(1,480)	80.9	(89.0)
OK	VI	See Arkansas (See Note)							
OR	X	See Alaska (See Note)							
PA	III	25,170	(27,690)	6,200	(6,800)	860	(950)	52.3	(57.5)
RI	I	710	(780)	180	(200)	26	(28)	1.5	(1.7)
SC	IV	See Delaware (See Note)							
SD	VIII	No Paint Plants							
TN	IV	4,140	(4,550)	1,020	(1,120)	128	(140)	8.7	(9.5)
TX	VI	24,600	(27,060)	6,080	(6,680)	830	(910)	51.1	(56.2)
UT	VIII	See Idaho (See Note)							
VT	I	See Maine (See Note)							
VA	III	4,390	(4,830)	1,090	(1,200)	136	(150)	9.1	(10.0)
WA	X	3,490	(3,840)	870	(950)	114	(125)	7.3	(8.0)
WV	III	See Delaware (See Note)							
WI	V	5,290	(5,820)	1,320	(1,440)	184	(202)	11.0	(12.2)
WY	VIII	No Paint Plants							
NATIONAL		450,020[1]	(495,020)[1]	111,100[2]	(122,160)	15,129	(16,637)	934.3	(1028.2)

NOTE: WITHHELD (BY CENSUS) TO AVOID DISCLOSING FIGURES FOR INDIVIDUAL COMPANIES.

[1] Contains approximately 6% water. [2] Contains approximately 24% water.

TABLE 44

QUANTITIES OF TOTAL PAINT & COATINGS INDUSTRY WASTES BY STATE - 1983
SIC 285
Mkg/yr (tons/yr)
(Wet Weight)

STATES	EPA REGIONS	TOTAL WASTE METRIC	TONS/YEAR	POTENTIALLY HAZARDOUS WASTE STREAM		HAZARDOUS SOLVENTS IN WASTE		TOXIC CHEMICAL COMPOUNDS IN WASTE	
AL, MS	IV	6,780	(7,460)	1,670	(1,840)	133	(146)	13	(14)
AK, OR	X	3,200	(3,520)	790	(870)	77	(84)	6	(7)
AZ	IX	1,120	(1,240)	270	(300)	21	(23)	2	(2)
AR, LA, OK	VI	4,640	(5,110)	1,140	(1,250)	128	(141)	9	(10)
CA	IX	89,280	(98,210)	22,100	(24,300)	2,180	(2,400)	172	(189)
CO	VIII	4,400	(4,840)	1,090	(1,200)	86	(95)	8	(9)
CT	I	1,070	(1,180)	260	(280)	37	(40)	2	(2)
DE,DC,WV,SC	III,IV	1,410	(1,550)	350	(380)	40	(44)	3	(3)
DC	III	See Delaware (See Note)							
FL	IV	14,630	(16,090)	3,560	(3,910)	294	(323)	28	(31)
GA	IV	32,950	(36,250)	8,150	(8,960)	710	(780)	63	(69)
HI	IX	No Paint Plants							
ID,MT,NV, NM,UT	X,VIII,IX VI,VIII	2,130	(2,340)	530	(580)	61	(67)	4	(4)
IL	V	59,490	(65,440)	14,700	(16,200)	1,830	(2,010)	113	(125)
IN	V	7,360	(8,090)	1,820	(2,010)	284	(313)	14	(15)
IA	VII	9,800	(10,780)	2,420	(2,660)	234	(257)	19	(21)
KS,NB	VII	1,830	(2,010)	460	(550)	40	(44)	3	(4)
KY	IV	52,550	(57,810)	13,000	(14,300)	960	(1,060)	100	(110)
LA	VI	See Arkansas (See Note)							
ME,NH,VT	I	570	(630)	140	(150)	21	(23)	1	(1)
MD	III	20,070	(22,070)	4,960	(5,450)	406	(447)	38	(42)
MA	I	7,320	(8,050)	1,810	(1,990)	234	(257)	14	(15)
MI	V	28,580	(31,430)	7,070	(7,770)	874	(960)	54	(60)
MN	V	7,310	(8,040)	1,810	(1,990)	178	(195)	14	(15)
MS	IV	See Alabama (See Note)							
MO	VII	29,340	(32,280)	7,250	(8,000)	721	(794)	58	(64)
MT	VIII	See Idaho (See Note)							
NB	VII	See Kansas (See Note)							
NV	IX	See Idaho (See Note)							
NH	I	See Maine (See Note)							
NJ	II	51,130	(56,240)	12,600	(13,900)	1,520	(1,670)	97	(107)
NM	VI	See Idaho (See Note)							
NY	II	26,570	(29,230)	6,560	(7,220)	790	(870)	51	(56)
NC	IV	17,730	(19,500)	2,990	(3,290)	360	(400)	34	(37)
ND	VIII	No Paint Plants							
OH	V	44,830	(49,320)	4,380	(4,820)	1,370	(1,500)	85	(94)
OK	VI	See Arkansas (See Note)							
OR	X	See Alaska (See Note)							
PA	III	29,830	(32,820)	11,100	(12,200)	890	(980)	57	(62)
RI	I	770	(850)	200	(220)	26	(28)	2	(2)
SC	IV	See Delaware (See Note)							
SD	VIII	No Paint Plants							
TN	IV	8,000	(8,800)	1,980	(2,170	147	(162)	15	(17)
TX	VI	31,670	(34,840)	7,830	(8,610)	870	(960)	60	(66)
UT	VIII	See Idaho (See Note)							
VT	I	See Maine (See Note)							
VA	III	7,680	(8,450)	1,900	(2,090)	145	(160)	15	(16)
WA	X	5,100	(5,610)	1,260	(1,390)	122	(134)	10	(11)
WV	III	See Delaware (See Note)							
WI	V	6,100	(6,710)	1,500	(1,660)	187	(206)	12	(13)
WY	VIII	No Paint Plants							
NATIONAL		615,240[1]	(676,800)[1]	147,650[2]	(162,510)[2]	15,976	(17,573)	1176	(1293)

NOTE: WITHHELD (BY CENSUS) TO AVOID DISCLOSING FIGURE FOR INDIVIDUAL COMPANIES.

[1] Contains approximately 7% water. [2] Contains approximately 28% water.

TABLE 45

QUANTITIES OF TOTAL PAINT AND COATINGS INDUSTRY WASTES BY EPA REGION - 1977 & 1983

SIC 285
kkg/yr (tons/yr)
(Wet Weight)

EPA Region	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
1977				
I	8,940(8,940)	2,220(2,450)	318(348)	18.5(20.4)
II	65,560(72,440)	16,200(17,809)	2,250(2,470)	136.3(150.0)
III	41,852(46,1[illegible])	10,332(11,391)	1,406(1,550)	86.9(95.8)
IV	72,903(80,378)	17,998(19,843)	2,449(2,700)	151.3(166.8)
V	133,800(147,190)	33,010(36,310)	4,614(5,078)	274.2(301.8)
VI	28,351(31,258)	6,999(7,717)	953(1,051)	58.8(64.8)
VII	27,550(30,320)	6,790(7,460)	926(1,022)	57.7(64.6)
VIII	2,700(2,977)	667(735)	91(100)	5.6(6.2)
IX	62,103(68,471)	15,332(16,904)	2,087(2,301)	128.9(142.1)
X	5,850(6,450)	1,445(1,593)	197(217)	12.1(13.3)
NATIONAL	449,609(495,147)[1]	110,993(122,203)[2]	15,291(16,837)	930.3(1,025.8)
1983				
I	9,730(10,710)	2,410(2,640)	318(348)	19.0(20.0)
II	77,700(85,470)	19,160(21,120)	2,310(2,540)	148.0(163.0)
III	58,448(64,441)	14,440(15,921)	1,515(1,670)	111.7(123.2)
IV	132,277(145,840)	32,680(36,031)	3,429(3,781)	252.8(278.7)
V	153,670(169,040)	37,795(41,533)	4,723(5,184)	292.0(322.0)
VI	36,914(40,699)	9,120(10,055)	957(1,055)	70.6(77.8)
VII	40,970(45,070)	10,130(11,210)	1,995(1,095)	80.0(89.0)
VIII	5,537(6,105)	1,368(1,508)	144(159)	10.6(11.7)
IX	91,056(100,393)	22,496(24,803)	2,361(2,603)	174.0(191.8)
X	8,613(9,496)	2,128(2,346)	223(246)	16.5(18.2)
NATIONAL	614,915(677,264)[3]	151,727(167,167)[4]	16,975(18,681)	1,175.2(1,295.4)

---

[1] Contains approximately 6% water. [2] Contains approximately 24% water. [3] Contains approximately 7% water.
[4] Contains approximately 28% water.

would cause the overall quantities of waste predicated on these levels of production to exceed those actually generated.

Increased use of water pollution control equipment will result in additional potentially hazardous waste sludges requiring disposal on land. If plants which presently discharge wastewater treatment wastes directly to a municipal treatment system are required to remove solids from this stream, large additional amounts of sludge will be generated for disposal with solid wastes. When calculating future waste quantities, it has been assumed that this change will not occur suddenly and that its influence will be partially offset by the development of new technology to treat or utilize wastewater sludges.

As discussed in more detail later, the use of solvents will be influenced by the slow trend towards water-based paints and new techniques in factory-applied coatings. The amount of solvents contained in wastes will also be affected by the growth in solvent recovery operations engendered by changing economics and virgin solvent availability.

While the use of solvents is estimated to increase at a rate of over four percent per year, the increase in solvent waste will be reduced to less than two percent in the near future, and will stabilize by 1983. The increase will be distorted geographically due to varying economics in different areas.

The extraplation of figures of this nature three and nine years into the future necessarily contains many unknowns which introduce unavoidable inaccuracies. The resulting estimates are as good as can be accurately predicted considering the many variables, but they are inherently less accurate than 1974 calculations given earlier.

Future Trends in Industry Subcategories

Solvent-Thinned Trade Sales Paints

The future for solvent-thinned trade sales paints appears to promise a steady decrease of the ratio of their production to water-thinned paints. The ease of application of the latter, the bright colors, the applicability over damp surfaces, and the ease of clean-up has made them very popular with do-it-yourself painters, a growing proportion of the trades sales market.

There are, of course, some uses in which water-thinned paints are not comparable, as yet, with solvent-thinned coatings. These include surfaces where high gloss (automobile refinishing), abrasion resistance (floor and deck paints), prolonged water immersion (marine paints), and a few other special properties are required, and a technological breakthrough will be necessary before water-thinned paints are widely used in these areas. However, most conventional trade s[illegible]nts are shifting to water, and this shift is [illegible]he next few years. It is estimated that by 1[illegible] solvent-thinned trade sales paints, except in ce[illegible] ields, will be less than half what it is today.

In the manufacturing area, roller mills appear to be generally on their way out. Those still in use are employed only because they are on hand; it is doubtful that many more will be bought. While pebble mills are still used for industrial paints, and may be used for trade sales products, if available, their use should decrease. Increasing use of sand mills, high-speed stone mills, and high-speed mixers may be expected. Expanded use of more easily dispersed (stir-in) pigments and pre-dispersed pigments may also be anticipated. Except for constituents which contain lead and mercury whose use may be regulated, little change in the use of potentially hazardous compounds may be expected in the manufacture of solvent-thinned trade sales paints.

The wastes of this subcategory are projected nationally and by state for 1977 and 1983 in Tables 46 and 47 and by EPA region in Table 48. These estimates include total waste, total potentially hazardous wastes, and total hazardous constituents. Tables 46 and 47 were derived in the same manner as the estimates in Table 43 and 44.

The projected national distribution of solvent-thinned trade sales paint wastes by waste stream in 1977 and 1983 is shown in Table 49. Projected production growth and waste data of surveyed plants were used in these extrapolations.

Water-Thinned Trade Sales Paints

Is is probable that the production of water-thinned coatings will continue to expand until it accounts for most trade sales products except those discussed above under solvent-thinned trades sales materials. Little change in the character or amount of waste per unit of product is to be expected in water-thinned coatings, unless mercury is controlled as discussed previously, although technological breakthroughs are always possible.

The above comments on trends in equipment usage in the production of solvent-thinned trade sales paints are also applicable to this subcategory.

The wastes of this subcategory are projected nationally and by state to 1977 and 1983 in Tables 50 and 51 and by EPA region in Table 52. These estimates include total waste, total potentially hazardous wastes, and total hazardous constituents. Tables 50 and 51 were derived in the same manner as the estimates in Table 43 and 44.

TABLE 46

QUANTITIES OF WASTES FROM MANUFACTURE OF
SOLVENT-THINNED TRADE SALES PAINTS BY STATE - 1977
SIC 28511 & 28513
kkg/yr*
(Wet Weight)**

STATE	EPA REGION	TOTAL WASTE	POTENTIALLY HAZARDOUS WASTE STREAM	HAZARDOUS SOLVENTS IN WASTE	TOXIC CHEMICAL COMPOUNDS IN WASTE
AL,MS	IV	847	212	40	3.3
AK,OR	X	506	127	24	2.0
AZ	IX	145	36	7	.6
AR,LA,OK	VI	827	207	39	3.2
CA	IX	14034	3516	658	55.0
CO	VIII	568	142	27	2.2
CT	I	227	57	11	.9
DE,DC,WV,SC	III,IV	269	67	13	1.1
DC	III	SEE DELAWARE			
FL	IV	1922	482	90	7.5
GA	IV	4330	1085	203	17.0
HI	IX	NO PAINT PLANTS			
ID,MT,NV NM,UT	X,VIII,IX VI,VIII	331	83	16	1.3
IL	V	11853	2970	556	46.5
IN	V	1467	368	69	5.8
IA	VII	1509	378	71	5.9
KS,NB	VII	279	70	13	1.1
KY	IV	6242	1564	293	24.5
LA	VI	SEE ARKANSAS			
ME,NH,VT	I	124	31	6	.5
MD	III	2635	660	124	10.3
MA	I	1550	388	73	6.1
MI	V	6128	1535	287	24.0
MN	V	1126	282	53	4.4
MS	IV	SEE ALABAMA			
MO	VII	4526	1134	212	17.7
MT	VIII	SEE IDAHO			
NB	VII	SEE KANSAS			
NV	IX	SEE IDAHO			
NH	I	SEE MAINE			
NJ	II	9910	2483	465	38.8
NM	VI	SEE IDAHO			
NY	II	5146	1269	241	20.2
NC	IV	2325	583	109	9.1
ND	VIII	NO PAINT PLANTS			
OH	V	8939	2239	419	35.0
OK	VI	SEE ARKANSAS			
OR	X	SEE ALASKA			
PA	III	5777	1447	271	22.6
RI	I	165	41	8	.6
SC	IV	SEE DELAWARE			
SD	VIII	NO PAINT PLANTS			
TN	IV	951	238	45	3.7
TX	VI	5653	1416	265	22.2
UT	VIII	SEE IDAHO			
VT	I	SEE MAINE			
VA	III	1013	254	48	4.0
WA	X	806	202	38	3.2
WV	III	SEE DELAWARE			
WI	V	1219	306	57	4.8
WY	VIII	NO PAINT PLANTS			
NATIONAL		103349	25892	4851	405.1

---

*To convert data to tons/yr, multiply by 1.1.

**Note: Wet Weight = Dry Weight

TABLE 47

QUANTITIES OF WASTES FROM MANUFACTURE OF
SOLVENT-THINNED TRADE SALES PAINTS BY STATE - 1983
SIC 28511 & 28513
kkg/yr*
(Wet Weight)**

STATE	EPA REGION	TOTAL WASTE	POTENTIALLY HAZARDOUS WASTE STREAM	HAZARDOUS SOLVENTS IN WASTE	TOXIC CHEMICAL COMPOUNDS IN WASTE
AL,MS	IV	1438	361	56	5.7
AK,OR	X	680	171	27	2.7
AZ	IX	235	59	9	.9
AR,LA,OK	VI	981	246	38	3.9
CA	IX	18975	4759	741	75.2
CO	VIII	942	236	37	3.7
CT	I	222	56	9	.9
DE,DC,MD,SC	III,IV	301	75	12	1.2
DC	III	SEE DELAWARE			
FL	IV	3060	768	119	12.1
GA	IV	7009	1758	274	27.8
HI	IX	NO PAINT PLANTS			
ID,MT,NV NM,UT	X,VIII,IX VI,VIII	459	115	18	1.8
IL	V	12645	3172	494	50.1
IN	V	1569	394	61	6.2
IA	VII	2079	522	81	8.2
KS,NB	VII	392	98	15	1.6
KY	IV	11168	2801	435	44.2
LA	VI	SEE ARKANSAS			
ME,NH,VT	I	118	30	5	.5
MD	III	4263	1069	165	16.9
MA	I	1556	390	61	6.2
MI	V	6081	1525	237	24.1
MN	V	1556	390	61	6.2
MS	IV	SEE ALABAMA			
MO	VII	6238	1565	243	24.7
MT	VIII	SEE IDAHO			
NB	VII	SEE KANSAS			
NV	IX	SEE IDAHO			
NH	I	SEE MAINE			
NJ	II	10567	2726	424	43.0
NM	VI	SEE IDAHO			
NY	II	5649	1417	220	22.4
NC	IV	3766	945	147	14.9
ND	VIII	NO PAINT PLANTS			
OH	V	9533	2391	372	37.8
OK	VI	SEE ARKANSAS			
OR	X	SEE ALASKA			
PA	III	6342	1591	248	25.1
RI	I	170	43	7	.7
SC	IV	SEE DELAWARE			
SD	VIII	NO PAINT PLANTS			
TN	IV	1700	426	66	6.7
TX	VI	6735	1689	263	26.7
UT	VIII	SEE IDAHO			
VT	I	SEE MAINE			
VA	III	1635	410	64	6.5
WA	X	1085	272	42	4.3
WV	III	SEE DELAWARE			
WI	V	1295	325	51	5.1
WY	VIII	NO PAINT PLANTS			
NATIONAL		130743	32795	5104	516.0

*To convert data to tons/yr, multiply by 1.1.

**Note: Wet Weight = Dry W

TABLE 48

QUANTITIES OF WASTES FROM MANUFACTURE OF SOLVENT-THINNED TRADE SALES PAINTS BY EPA REGION - 1977 & 1983
SIC 28511 & 28513
kkg/yr (tons/yr)
(Wet Weight)*

EPA Region	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
1977				
I	2,066(2,273)	517(569)	98(108)	8.1(8.9)
II	15,056(16,636)	3,772(4,149)	706(777)	59.0(64.9)
III	9,611(10,596)	2,408(2,655)	451(497)	37.7(41.6)
IV	16,741(18,458)	4,194(4,624)	785(865)	65.6(72.3)
V	30,732(33,805)	7,700(8,470)	1,441(1,585)	120.5(132.5)
VI	6,510(7,178)	1,631(1,798)	305(336)	25.5(28.1)
VII	6,314(6,945)	1,582(1,740)	296(326)	24.7(27.2)
VIII	620(684)	155(171)	29(32)	2.4(2.6)
IX	14,260(15,722)	3,573(3,939)	669(738)	55.9(61.6)
X	1,343(1.481)	337(371)	63(69)	5.3(5.8)
NATIONAL	103,253(113,778)	25,869(28,486)	4,843(5,334)	404.7(446.2)
1983				
I	2,066(2,273)	519(571)	82(90)	8.3(9.1)
II	16,516(18,168)	4,143(4,557)	644(708)	65.4(71.9)
III	12,423(13,699)	3,116(3,436)	485(535)	49.2(54.2)
IV	28,115(30,998)	7,052(7,775)	1,098(1,211)	111.4(122.8)
V	32,679(35,947)	8,197(9,017)	1,276(1,407)	129.5(142.4)
VI	7,846(8,650)	1,968(2,170)	306(337)	31.1(34.3)
VII	8,709(9,580)	2,185(2,404)	329(373)	34.5(38.0)
VIII	1,177(1,298)	295(325)	46(51)	4.7(5.2)
IX	19,354(21,338)	4,854(5,352)	755(832)	76.7(84.6)
X	1,831(2,019)	4,590(5,061)	71(78)	7.2(7.9)
NATIONAL	130,716(143,970)	32,757(36,112)	5,102(5,622)	518.0(570.2)

*Note: Net Weight = Dry Weight

TABLE 49

QUANTITIES OF WASTE STREAMS BY SOURCE - 1977 & 1983
SOLVENT-THINNED TRADE SALES PAINTS
SIC 28511 & 28513
kkg/yr (tons/yr)
(Wet Weight) *

Waste Stream	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
1977				
Cleanings	22,000(24,256)	22,000(24,256)	4,620(5,094)	280(309)
Raw Material Packaging	78,400(86,439)	990(1,092)	---	62(68)
Air Pollution Collection	400(441)	400(441)	---	40(44)
Spoiled Batches	1,000(1,103)	1,000(1,103)	200(221)	20(22)
Spills	1,500(1,654)	1,500(1,654)	28(31)	3(3)
TOTAL	103,300(113,893)	25,890(28,546)	4,848(5,346)	405(446)
1983				
Cleanings	27,900(30,761)	27,900(30,761)	5,070(5,590)	360(397)
Raw Material Packaging	99,230(109,405)	1,260(1,389)	---	80(88)
Air Pollution Collection	520(573)	520(573)	---	50(55)
Spoiled Batches	1,300(1,433)	1,300(1,433)	20(22)	25(28)
Spills	1,820(2,007)	1,820(2,007)	11(12)	3(3)
TOTAL	130,770(144,179)	32,800(36,163)	5,101(5,624)	518(571)

*Note: Wet Weight = Dry Weight

TABLE 50

QUANTITIES OF WASTES FROM MANUFACTURE OF WATER-THINNED TRADE SALES PAINTS BY STATE - 1977
SIC 28512 & 28514
kkg/yr*
(Wet Weight)

STATE	EPA REGION	TOTAL WASTE	POTENTIALLY HAZARDOUS WASTE STREAM	HAZARDOUS SOLVENTS IN WASTE	TOXIC CHEMICAL COMPOUNDS IN WASTE
AL,MS	IV	1184	287	------	.5
AK,OR	X	708	171	------	.3
AZ	IX	202	49	------	.1
AR,LA,OK	VI	1155	280	------	.5
CA	IX	19608	4748	------	9.1
CO	VIII	794	192	------	.4
CT	I	318	77	------	.1
DE,DC,WV,SC	III,IV	375	91	------	.2
DC	III	SEE DELAWARE			
FL	IV	2686	650	------	1.2
GA	IV	6050	1465	------	2.8
HI	IX	NO PAINT PLANTS			
ID,MT,NV	X,VIII,IX				
NM,UT	VI,VIII	462	112	------	.2
IL	V	16562	4010	------	7.7
IN	V	2050	496	------	1.0
IA	VII	2108	510	------	1.0
KS,NB	VII	390	94	------	.2
KY	IV	8721	2112	------	4.0
LA	VI	SEE ARKANSAS			
ME,NH,VT	I	173	42	------	.1
MD	III	3682	891	------	1.7
MA	I	2166	524	------	1.0
MI	V	8562	2073	------	4.0
MN	V	1574	381	------	.7
MS	IV	SEE ALABAMA			
MO	VII	6324	1531	------	2.9
MT	VIII	SEE IDAHO			
NB	VII	SEE KANSAS			
NV	IX	SEE IDAHO			
NH	I	SEE MAINE			
NJ	II	13847	3353	------	6.4
NM	VI	SEE IDAHO			
NY	II	7191	1741	------	3.3
NC	IV	3249	787	------	1.5
ND	VIII	NO PAINT PLANTS			
OH	V	12490	3024	------	5.8
OK	VI	SEE ARKANSAS			
OR	X	SEE ALASKA			
PA	III	8071	1954	------	3.7
RI	I	231	56	------	.1
SC	IV	SEE DELAWARE			
SD	VIII	NO PAINT PLANTS			
TN	IV	1326	322	------	.6
TX	VI	7898	1912	------	3.7
UT	VIII	SEE IDAHO			
VT	I	SEE MAINE			
VA	III	1415	343	------	.7
WA	X	1126	273	------	.5
WV	III	SEE DELAWARE			
WI	V	1704	413	------	.8
WY	VIII	NO PAINT PLANTS			
NATIONAL		144404[1]	34964[2]		66.8

---

*To convert data to tons/yr, multiply by 1.1.

[1] Contains approximately [illegible] water. [2] Contains approximately 75% water.

TABLE 51

QUANTITIES OF WASTES FROM MANUFACTURE OF
WATER-THINNED TRADE SALES PAINTS BY STATE - 1983
SIC 28512 & 28514
kkg/yr*
(Wet Weight)

STATE	EPA REGION	TOTAL WASTE	POTENTIALLY HAZARDOUS WASTE STREAM	HAZARDOUS SOLVENTS IN WASTE	TOXIC CHEMICAL COMPOUNDS IN WASTE
AL,MS	IV	2535	616	------	1.1
AK,OR	X	1195	290	------	.5
AZ	IX	415	100	------	.2
AR,LA,OK	VI	1729	419	------	.8
CA	IX	33435	8098	------	14.9
CO	VIII	1659	402	------	.7
CT	I	392	95	------	.2
DE,DC,WV,SC	III,IV	530	128	------	.2
DC	III	SEE DELAWARE			
FL	IV	5392	1306	------	2.4
GA	IV	12351	2991	------	5.5
HI	IX	NO PAINT PLANTS			
ID,MT,NV	X,VIII,IX				
NM,UT	VI,VIII	807	195	------	.4
IL	V	22283	5397	------	10.0
IN	V	2765	670	------	1.2
IA	VII	3654	837	------	1.6
KS,NB	VII	691	167	------	.3
KY	IV	19579	4766	------	8.8
LA	VI	SEE ARKANSAS			
ME,NH,VT	I	207	50	------	.1
MD	III	7912	1919	------	3.4
MA	I	2742	664	------	1.2
MI	V	10715	2595	------	4.8
MN	V	2742	664	------	1.2
MS	IV	SEE ALABAMA			
MO	VII	10992	2662	------	4.9
MT	VIII	SEE IDAHO			
NB	VII	SEE KANSAS			
NV	IX	SEE IDAHO			
NH	I	SEE MAINE			
NJ	II	19149	4638	------	8.6
NM	VI	SEE IDAHO			
NY	II	9955	2411	------	4.4
NC	IV	6636	1607	------	3.0
ND	VIII	NO PAINT PLANTS			
OH	V	16798	4069	------	7.5
OK	VI	SEE ARKANSAS			
OR	X	SEE ALASKA			
PA	III	11176	2707	------	5.0
RI	I	300	73	------	.1
SC	IV	SEE DELAWARE			
SD	VIII	NO PAINT PLANTS			
TN	IV	2995	725	------	1.3
TX	VI	11657	2374	------	5.3
UT	VIII	SEE IDAHO			
VT	I	SEE MAINE			
VA	III	2880	698	------	1.3
WA	X	1913	463	------	.9
WV	III	SEE DELAWARE			
WI	V	2281	553	------	1.0
WY	VIII	NO PAINT PLANTS			
NATIONAL		230350[1]	55798[2]		102.8

[1] Contains approximately [illegible] water. [2] Contains approximately [illegible] water.

*To convert [illegible]

147

TABLE 52

QUANTITIES OF WASTES FROM MANUFACTURE OF WATER-THINNED TRADE SALES PAINTS BY EPA REGION - 1977 & 1983
SIC 28512 & 28514
kkg/yr (tons/yr)
(Wet Weight)

EPA Region	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
1977				
I	2,888(3,184)	699(771)	---	1.3(1.4)
II	21,038(23,142)	5,094(5,603)	---	9.7(10.7)
III	13,428(14,805)	3,251(3,584)	---	6.2(6.8)
IV	23,391(25,789)	5,663(6,244)	---	10.8(11.9)
V	42,942(47,236)	10,397(11,437)	---	20.0(22.1)
VI	9,097(10,030)	2,202(2,428)	---	4.2(4.6)
VII	8,822(9,704)	2,135(2,348)	---	4.1(4.5)
VIII	8,660(9,548)	210(232)	---	0.4(0.4)
IX	19,926(21,969)	4,825(5,320)	---	9.3(10.3)
X	1,877(2,069)	455(502)	---	0.9(1.0)
NATIONAL	144,275(158,883)[1]	34,931(38,468)[2]	---	66.9(73.8)
1983				
I	3,641(4,005)	882(970)	---	1.6(1.8)
II	29,104(32,014)	7,049(7,754)	---	13.0(14.3)
III	21,891(24,136)	5,302(5,846)	---	9.8(10.8)
IV	49,542(54,622)	11,999(13,229)	---	22.1(24.4)
V	57,584(63,342)	13,948(15,343)	---	25.7(28.7)
VI	13,826(15,244)	3,349(3,692)	---	6.2(6.8)
VII	15,347(16,882)	3,716(4,088)	---	6.8(7.5)
VIII	2,074(2,287)	502(553)	---	0.9(1.0)
IX	34,104(37,601)	8,260(9,107)	---	15.3(16.9)
X	3,226(3,557)	781(861)	---	1.4(1.5)
NATIONAL	230,339(253,688)[3]	55,788(61,444)[4]	---	102.8(113.4)

---

[1] Contains approximately 20% water. [2] Contains approximately 75% water. [3] Contains approximately 20% water. [4] Contains approximately 75% water.

The projected national distribution of water-thinned trade sales paint wastes by waste stream in 1977 and 1983 is shown in Table 53. Projected production growth and waste data of surveyed plants were used in these extrapolations.

Lacquers

The production of nitrocellulose lacquers has been decreasing in recent years, and it is expected that this trend will continue. There is a growing tendency to replace nitrocellulose with other resins such as acrylics, styrenated alkyds, and urea or melamine coatings.

Lacquers by definition have the disadvantage of remaining soluble in the solvent with which they are made. Thus, thermosetting or oxidizing coatings are more attractive when they can be produced with properties competitive with lacquers. The trend in the industry to reduce the solvent content of coatings, encouraged by air pollution control regulations encourages the replacement of lacquers with other coatings.

Most of the non-nitrocelluse lacquers are highly specialized coatings and only the availability of non-lacquers with suitable properties will reduce their use. However, the quantity is so small that it will have little effect on the overall trends.

The wastes of this subcategory are projected nationally and by state to 1977 and 1983 in Tables 54 and 55 and by EPA region in Table 56. These estimates include total wastes, total potentially hazardous wastes, and total hazardous constituents.

Tables 54 and 55 were derived in the same manner as the estimates in Tables 43 and 44.

The projected national distribution of lacquer wastes by waste stream for 1977 and 1983 is shown in Table 57. Projected production growth and waste data of surveyed plants were used in these extrapolations.

Factory-Applied Coatings

The NPCA has estimated a substantial reduction in the manufacture of solvent-thinned paints for industrial use by 1980, with a concomitant increase in the use of high-solids, water-thinned, and powder coatings. A moving force behind this trend has been pressure from customers initiated by the adoption of Rule 66 by Los Angeles County in 1966, and the spread of similar regulations in recent years to about 16 states. This type of regulation restricts the use of solvents on the basis of their relative photochemical reactivity. Another reason for this decline is customer pressure to reduce or eliminate flammable or toxic

TABLE 53

QUANTITIES OF WASTE STREAMS BY SOURCE - 1977 & 1983
WATER-THINNED TRADE SALES PAINTS
SIC 28512 & 28514
kkg/yr (tons/yr)
(Wet Weight)

Waste Stream	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Components In Waste
1977				
Cleanings	30,760(33,914)[1]	30,760(33,914)[1]	---	46(51)
Raw Material Packaging	109,590(120,827)	160(176)	---	10(11)
Air Pollution Collection	580(639)	580(639)	---	6(7)
Spoiled Batches	1,440(1,588)[2]	1,440(1,588)[2]	---	3(3)
Spills	2,020(2,227)[2]	2,020(2,227)[2]	---	1(1)
TOTAL	144,390(159,195)[2]	34,960(38,544)[3]	---	66(73)
1983				
Cleanings	49,100(54,135)[1]	49,100(54,135)[1]	---	72(79)
Raw Material Packaging	174,380(192,811)	260(287)	---	16(18)
Air Pollution Collection	920(1,014)	920(1,014)	---	10(11)
Spoiled Batches	2,300(2,536)[2]	2,300(2,536)[2]	---	5(6)
Spills	3,230(3,561)[2]	3,230(3,561)[2]	---	<1(1)
TOTAL	230,430(254,057)[2]	55,810(61,533)[3]	---	103(114)

---

[1] Contains approximately 92% water. [2] Contains approximately 20% water. [3] Contains approximately 7[illegible] water.

TABLE 54

QUANTITIES OF WASTES FROM MANUFACTURE OF
INDUSTRIAL & NON-INDUSTRIAL LACQUERS BY STATE - 1977
SIC 28515 & 28517
kkg/yr*
(Wet Weight)**

STATE	EPA REGION	TOTAL WASTE	POTENTIALLY HAZARDOUS WASTE STREAM	HAZARDOUS SOLVENTS IN WASTE	TOXIC CHEMICAL COMPOUNDS IN WASTE
AL,MS	IV	247	60	24	.1
AK,OR	X	148	36	14	0
AZ	IX	42	10	4	0
AR,LA,OK	VI	241	58	23	.1
CA	IX	4092	969	391	1.3
CO	VIII	166	40	16	.1
CT	I	66	16	6	0
DE,DC,WV,SC	III,IV	78	19	7	0
DC	III	SEE DELAWARE			
FL	IV	560	135	54	.2
GA	IV	1262	305	121	.4
HI	IX	NO PAINT PLANTS			
ID,MT,NV NM,UT	X,VIII,IX VI,VIII	96	23	9	0
IL	V	3456	835	330	1.1
IN	V	428	103	41	.1
IA	VII	440	106	42	.1
KS,NB	VII	81	20	8	0
KY	IV	1820	440	174	.6
LA	VI	SEE ARKANSAS			
ME,NH,VT	I	36	9	3	0
MD	III	768	186	73	.2
MA	I	452	109	43	.1
MI	V	1787	432	171	.6
MN	V	328	79	31	.1
MS	IV	SEE ALABAMA			
MO	VII	1320	319	126	.4
MT	VIII	SEE IDAHO			
NB	VII	SEE KANSAS			
NV	IX	SEE IDAHO			
NH	I	SEE MAINE			
NJ	II	2889	699	276	.9
NM	VI	SEE IDAHO			
NY	II	1500	363	143	.5
NC	IV	678	164	65	.2
ND	VIII	NO PAINT PLANTS			
OH	V	2606	630	249	.8
OK	VI	SEE ARKANSAS			
OR	X	SEE ALASKA			
PA	III	1684	407	161	.5
RI	I	48	12	5	0
SC	IV	SEE DELAWARE			
SD	VIII	NO PAINT PLANTS			
TN	IV	277	67	26	.1
TX	VI	1648	398	158	.5
UT	VIII	SEE IDAHO			
VT	I	SEE MAINE			
VA	III	295	71	28	.1
WA	X	235	57	22	.1
WV	III	SEE DELAWARE			
WI	V	356	86	34	.1
WY	VIII	NO PAINT PLANTS			
NATIONAL		30130	7283	2878	9.3

---

*To convert data to tons/yr, multiply by 1.1.
**Note: Wet Weight = Dry Weight

TABLE 55

QUANTITIES OF WASTES FROM MANUFACTURE OF
INDUSTRIAL & NON-INDUSTRIAL LACQUERS BY STATE - 1983
SIC 28515 & 28517
kkg/yr*
(Wet Weight)**

STATE	EPA REGION	TOTAL WASTE	POTENTIALLY HAZARDOUS WASTE STREAM	HAZARDOUS SOLVENTS IN WASTE	TOXIC CHEMICAL COMPOUNDS IN WASTE
AL,MS	IV	441	106	34	.1
AK,OR	X	208	50	16	.1
AZ	IX	72	17	6	0
AR,LA,OK	VI	301	72	23	.1
CA	IX	5814	1401	445	1.9
CO	VIII	289	69	22	.1
CT	I	68	16	5	0
DE,DC,WV,SC	III,IV	92	22	7	0
DC	III	SEE DELAWARE			
FL	IV	936	226	72	.3
GA	IV	2148	517	184	.7
HI	IX	NO PAINT PLANTS			
ID,MT,NV	X,VIII,IX				
NM,UT	VI,VIII	140	34	11	0
IL	V	3875	933	297	1.3
IN	V	481	116	37	.2
IA	VII	637	153	49	.2
KS,NB	VII	120	29	9	0
KY	IV	3422	824	262	1.1
LA	VI	SEE ARKANSAS			
ME,NH,VT	I	36	9	3	0
MD	III	1306	315	100	.4
MA	I	477	115	37	.2
MI	V	1863	449	143	.6
MN	V	477	115	37	.2
MS	IV	SEE ALABAMA			
MO	VII	1911	460	146	.6
MT	VIII	SEE IDAHO			
NB	VII	SEE KANSAS			
NV	IX	SEE IDAHO			
NH	I	SEE MAINE			
NJ	II	3330	802	255	1.1
NM	VI	SEE IDAHO			
NY	II	1731	417	133	.6
NC	IV	1154	278	88	.4
ND	VIII	NO PAINT PLANTS			
OH	V	2921	704	224	1.0
OK	VI	SEE ARKANSAS			
OR	X	SEE ALASKA			
PA	III	1943	468	149	.6
RI	I	52	13	4	0
SC	IV	SEE DELAWARE			
SD	VIII	NO PAINT PLANTS			
TN	IV	521	125	40	.2
TX	VI	2064	497	158	.7
UT	VIII	SEE IDAHO			
VT	I	SEE MAINE			
VA	III	501	121	38	.2
WA	X	333	80	25	.1
WV	III	SEE DELAWARE			
WI	V	397	96	30	.1
WY	VIII	NO PAINT PLANTS			
NATIONAL		40068	9649	3069	13.1

---

*To convert data to tons/yr, multiply by 1.1.
**Note: Wet Weight = Dry Weight

TABLE 56

QUANTITIES OF WASTES FROM MANUFACTURE OF INDUSTRIAL AND NON-INDUSTRIAL LACQUERS BY EPA REGION - 1977 & 1983

SIC 28515 & 28517

kkg/yr (tons/yr)

(Wet Weight)*

1977 EPA Region	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
I	602(664)	146(161)	57(63)	0.1(0.1)
II	4,389(4,828)	1,062(1,168)	419(464)	1.4(1.5)
III	2,802(3,089)	677(746)	268(295)	0.9(1.0)
IV	4,881(5,381)	1,180(1,301)	467(515)	1.5(1.7)
V	8,961(9,857)	2,165(2,382)	856(942)	2.8(3.1)
VI	1,898(2,093)	459(506)	181(200)	0.6(0.7)
VII	1,841(2,025)	445(490)	176(194)	0.5(0.6)
VIII	181(200)	44(49)	17(19)	0.1(0.1)
IX	4,158(4,584)	1,005(1,108)	397(438)	1.3(1.4)
X	392(432)	95(105)	37(41)	0.1(0.1)
NATIONAL	30,105(33,153)	7,278(8,015)	2,875(3,170)	9.3(10.3)
1983				
I	633(696)	153(168)	49(54)	0.2(0.2)
II	5,067(5,567)	1,219(1,341)	388(427)	1.7(1.9)
III	3,807(4.197)	917(1,011)	292(322)	1.2(1.3)
IV	8,615(9,498)	2,075(2,288)	660(728)	2.8(3.1)
V	10,014(11,015)	2,413(2,660)	768(845)	3.4(3.7)
VI	2,404(2,650)	580(639)	184(203)	0.8(0.9)
VII	2,668(2,933)	642(706)	204(224)	0.8(0.9)
VIII	361(398)	87(96)	28(31)	0.1(0.1)
IX	5,930(6,538)	1,427(1,573)	454(501)	1.9(2.1)
X	561(619)	135(149)	43(47)	0.2(0.2)
NATIONAL	40,054(44,114)	9,648(10,632)	3,070(3,381)	13.1(14.4)

*Note: Wet Weight = Dry Weight

TABLE 57

QUANTITIES OF WASTE STREAMS BY SOURCE - 1977 & 1983
INDUSTRIAL AND NON-INDUSTRIAL LACQUERS
SIC 28515 & 28517
kkg/yr (tons/yr)
(Wet Weight) *

Waste Stream	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
1977				
Cleanings	6,420(7,078)	6,420(7,078)	2,740(3,021)	6.7(7.4)
Raw Material Packaging	22,870(25,215)	24(26)	---	1.5(1.7)
Air Pollution Collection	120(132)	120(132)	---	1.0(1.1)
Spoiled Batches	300(331)	300(331)	130(143)	0.4(0.4)
Spills	420(463)	420(463)	16(18)	---
TOTAL	30,130(33,219)	7,284(8,030)	2,886(3,182)	9.6(10.6)
1983				
Cleanings	8,500(9,372)	8,500(9,372)	2,920(3,219)	9.0(9.9)
Raw Material Packaging	30,450(33,572)	32(35)	---	2.0(2.2)
Air Pollution Collection	160(176)	160(176)	---	1.0(1.1)
Spoiled Batches	400(441)	400(441)	103(114)	1.0(1.1)
Spills	560(617)	560(617)	20(22)	---
TOTAL	40,070(44,178)	9,652(10,641)	3,043(3,355)	13.0(14.3)

*Note: Wet Weight = Dry Weight

solvents for reasons of fire hazards and increasing insurance costs. Industrial hygiene and odor problems in the neighborhood and, recently, serious shortages and increased costs of petroleum-derived solvents have all also contributed to this trend as well.

At the present time, the above emerging technologies have been adopted by certain industries for certain purposes, but are not necessarily useful for all industries for all purposes. For example, powder coatings cannot be used on any substrates which cannot be heated to the fusion point of the resin. This, in general, rules out the use of these coatings on wood or paper. Electrocoating, which uses a water-thinned coating, is often only effective for a single coat, usually the primer. Today, a solvent-thinned paint must still be used for the top coat. Ultimately, solvent-thinned paints will be largely replaced by other coatings, which will reduce or eliminate the use of solvents, but the time when this conversion is complete is difficult to foresee.

The wastes of this subcategory are projected nationally and by state for 1977 and 1983 in Tables 58 and 59 and by EPA region in Table 60. These estimates include total wastes, total potentially hazardous wastes, and total hazardous constituents. Tables 58 and 59 were derived in the same manner as the estimates in Tables 43 and 44.

The projected national distribution of factory-applied coatings wastes by waste stream in 1977 and 1983 is shown in Table 61. Projected production growth and waste data of surveyed plants were used in these extrapolations.

Putty and Miscellaneous Products

It is probable that calking compounds will replace putty in some uses in the future. Calking is more flexible and shows less tendency to crack with age, particularly on somewhat flexible substrates. It is estimated that the production of putty will remain at about the current level over the next 10 years even though total paint production increases. Any technical improvements in putty are likely to move more of its production over into the calking compound SIC grouping which is outside SIC 285. The growth rate of miscellaneous paint products including thinners, aerosol paints, and pigment dispersions, is expected to increase at a modest rate of about six percent over the next eight years.

The waste of this subcategory are projected nationally and by state to 1977 and 1983 in Tables 62 and 63 and by EPA region in Table 64. These estimates include total wastes, total potentially hazardous wastes, and total hazardous constituents. Tables 62 and 63 were derived in the same manner as the estimates in Tables 43 and 44.

TABLE 58

QUANTITIES OF WASTES FROM MANUFACTURE OF
FACTORY-APPLIED COATINGS BY STATE - 1977
SIC 28516
kkg/yr*
(Wet Weight)**

STATE	EPA REGION	TOTAL WASTE	POTENTIALLY HAZARDOUS WASTE STREAM	HAZARDOUS SOLVENTS IN WASTE	TOXIC CHEMICAL COMPOUNDS IN WASTE
AL,MS	IV	1010	249	47	3.0
AK,OR	X	603	149	28	1.8
AZ	IX	172	42	8	.5
AR,LA,OK	VI	985	243	46	2.9
CA	IX	16721	4120	780	50.0
CO	VIII	677	167	32	2.0
CT	I	271	67	13	.8
DE,DC,WV,SC	III,IV	320	79	15	1.0
DC	III	SEE DELAWARE			
FL	IV	2293	564	107	6.8
GA	IV	5159	1271	241	15.4
HI	IX	NO PAINT PLANTS			
ID,MT,NV	X,VIII,IX				
NM,UT	VI,VIII	394	97	18	1.2
IL	V	14123	3460	659	42.2
IN	V	1743	431	82	5.2
IA	VII	1798	443	84	5.4
KS,NB	VII	332	82	16	1.0
KY	IV	7437	1833	347	22.2
LA	VI	SEE ARKANSAS			
ME,NH,VT	I	148	36	7	.4
MD	III	3140	774	146	9.4
MA	I	1847	455	86	5.5
MI	V	7302	1799	341	21.6
MN	V	1342	331	63	4.0
MS	IV	SEE ALABAMA			
MO	VII	5393	1329	252	16.1
MT	VIII	SEE IDAHO			
NB	VII	SEE KANSAS			
NV	IX	SEE IDAHO			
NH	I	SEE MAINE			
NJ	II	11803	2910	551	35.3
NM	VI	SEE IDAHO			
NY	II	6132	1511	286	18.3
NC	IV	2770	683	129	8.3
ND	VIII	NO PAINT PLANTS			
OH	V	10651	2624	497	31.8
OK	VI	SEE ARKANSAS			
OR	X	SEE ALASKA			
PA	III	6833	1696	321	20.6
RI	I	197	49	9	.5
SC	IV	SEE DELAWARE			
SD	VIII	NO PAINT PLANTS			
TN	IV	1133	279	53	3.4
TX	VI	6733	1660	314	20.1
UT	VIII	SEE IDAHO			
VT	I	SEE MAINE			
VA	III	1207	297	55	3.6
WA	X	960	237	45	2.9
WV	III	SEE DELAWARE			
WI	V	1453	358	68	4.3
WY	VIII	NO PAINT PLANTS			
NATIONAL		123141	30335	5747	357.9

*[illegible]

**[illegible]

TABLE 59

QUANTITIES OF WASTES FROM MANUFACTURE OF
FACTORY-APPLIED COATINGS BY STATE - 1983
SIC 28516
kkg/yr*
(Wet Weight)**

STATE	EPA REGION	TOTAL WASTE	POTENTIALLY HAZARDOUS WASTE STREAM	HAZARDOUS SOLVENTS IN WASTE	TOXIC CHEMICAL COMPOUNDS IN WASTE
AL,MS	IV	1586	394	65	4.8
AK,OR	X	750	186	31	2.2
AZ	IX	260	64	11	.8
AR,LA,OK	VI	1082	268	45	3.2
CA	IX	20925	5192	861	62.7
CO	VIII	1038	258	43	3.1
CT	I	245	61	10	.7
DE,DC,WV,SC	III,IV	332	82	14	1.0
DC	III	SEE DELAWARE			
FL	IV	3375	837	139	10.1
GA	IV	7730	1918	318	23.2
HI	IX	NO PAINT PLANTS			
ID,MT,NV	X,VIII,IX				
NM,UT	VI,VIII	505	125	21	1.5
IL	V	13945	3460	574	41.8
IN	V	1731	429	71	5.2
IA	VII	2293	569	94	6.9
KS,NB	VII	433	107	16	1.3
KY	IV	12316	3056	507	36.9
LA	VI	SEE ARKANSAS			
ME,NH,VT	I	130	32	5	.4
MD	III	4701	1166	194	14.1
MA	I	1715	426	71	5.1
MI	V	6705	1664	276	20.1
MN	V	1716	426	71	5.1
MS	IV	SEE ALABAMA			
MO	VII	6879	1707	283	20.6
MT	VIII	SEE IDAHO			
NB	VII	SEE KANSAS			
NV	IX	SEE IDAHO			
NH	I	SEE MAINE			
NJ	II	11984	2973	493	35.9
NM	VI	SEE IDAHO			
NY	II	6230	1546	256	18.7
NC	IV	4153	1030	171	12.4
ND	VIII	NO PAINT PLANTS			
OH	V	10513	2608	433	31.5
OK	VI	SEE ARKANSAS			
OR	X	SEE ALASKA			
PA	III	6994	1735	288	21.0
RI	I	187	47	8	.6
SC	IV	SEE DELAWARE			
SD	VIII	NO PAINT PLANTS			
TN	IV	1875	465	77	5.6
TX	VI	7427	1843	306	22.2
UT	VIII	SEE IDAHO			
VT	I	SEE MAINE			
VA	III	1803	447	74	5.4
WA	X	1197	297	49	3.6
WV	III	SEE DELAWARE			
WI	V	1428	354	59	4.3
WY	VIII	NO PAINT PLANTS			
NATIONAL		144185	35772	5936	432.0

---

*To convert data to tons/yr, multiply by 1.1.
**Note: Wet Weight = Dry Weight

TABLE 60

QUANTITIES OF WASTES FROM MANUFACTURE OF FACTORY-APPLIED COATINGS BY EPA REGION - 1977 & 1983
SIC 28516
kkg/yr (tons/yr)
(Wet Weight) *

1977 EPA Region	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
I	2,463(2,709)	607(665)	115(127)	7.3(8.0)
II	17,946(19,734)	4,431(4,863)	837(921)	53.6(59.0)
III	11,451(12,625)	2,822(3,111)	534(589)	34.2(37.7)
IV	19,947(21,992)	4,915(5,419)	930(1,025)	59.6(65.7)
V	36,619(40,455)	9,023(9,925)	1,710(1,881)	109.3(120.2)
VI	7,757(8,552)	1,911(2,107)	362(399)	23.2(25.6)
VII	7,523(8,275)	1,854(2,039)	352(387)	22.5(24.8)
VIII	739(815)	182(201)	34(37)	2.2(2.4)
IX	16,992(18,734)	4,187(4,616)	793(874)	50.8(56.0)
X	1,601(1,765)	394(434)	75(83)	4.8(5.3)
NATIONAL	123,032(135,484)	30,316(33,385)	5,742(6,323)	367.5(404.7)
1983				
I	2,278(2,506)	566(623)	94(103)	6.8(7.5)
II	18,214(20,035)	4,519(4,971)	749(824)	54.6(60.1)
III	13,700(15,105)	3,399(3,748)	564(622)	41.0(45.2)
IV	31,005(34,184)	7,693(8,482)	1,276(1,407)	93.0(102.5)
V	36,039(39,643)	8,941(9,835)	1,484(1,636)	108.0(119.1)
VI	8,653(9,540)	2,147(2,367)	356(393)	25.9(28.6)
VII	9,605(10,565)	2,397(2,643)	395(434)	28.8(31.7)
VIII	1,298(1,431)	322(355)	53(58)	3.9(4.3)
IX	21,343(23,531)	5,295(5,838)	879(969)	63.9(70.5)
X	2,019(2,226)	501(552)	83(92)	6.1(6.7)
NATIONAL	144,154(158,766)	35,780(39,414)	5,933(6,537)	432.0(476.1)

*Note: Wet Weight = Dry Weight

TABLE 61

QUANTITIES OF WASTE STREAMS BY SOURCE - 1977 & 1983
FACTORY-APPLIED COATINGS
SIC 28516
kkg/yr (tons/yr)
(Wet Weight)*

Waste Stream	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
1977				
Cleanings	25,230(27,817)	25,230(27,817)	5,470(6,031)	256(282)
Raw Material Packaging	93,460(103,043)	670(739)	---	56(62)
Air Pollution Collection	490(540)	490(540)	---	35(39)
Spoiled Batches	2,230(2,459)	2,230(2,459)	240(265)	18(20)
Spills	1,720(1,896)	1,720(1,896)	32(35)	3(3)
TOTAL	123,130(135,755)	30,340(33,451)	5,742(6,331)	368(406)
1983				
Cleanings	29,700(32,745)	29,700(32,745)	5,660(6,240)	300(331)
Raw Material Packaging	109,490(120,717)	1,060(1,169)	---	66(73)
Air Pollution Collection	580(639)	580(639)	---	42(46)
Spoiled Batches	2,440(2,690)	2,440(2,690)	240(265)	21(23)
Spills	2,000(2,205)	2,000(2,205)	35(39)	3(3)
TOTAL	144,210(158,996)	35,780(39,448)	5,935(6,544)	432(476)

*Note: Wet Weight = Dry Weight

TABLE 62

QUANTITIES OF WASTES FROM MANUFACTURE OF
PUTTY & MISCELLANEOUS PAINT PRODUCTS BY STATE - 1977
SIC 28518 & 28519
kkg/yr*
(Wet Weight)**

STATE	EPA REGION	TOTAL WASTE	POTENTIALLY HAZARDOUS WASTE STREAM	HAZARDOUS SOLVENTS IN WASTE	TOXIC CHEMICAL COMPOUNDS IN WASTE
AL,MS	IV	401	98	14	.7
AK,OR	X	240	59	8	.4
AZ	IX	68	17	2	.1
AR,LA,OK	VI	391	96	13	.7
CA	IX	6641	1630	228	11.7
CO	VIII	269	66	9	.5
CT	I	108	26	4	.2
DE,DC,WV,SC	III,IV	127	31	4	.2
DC	III	SEE DELAWARE			
FL	IV	910	223	31	1.6
GA	IV	2049	503	70	3.6
HI	IX	NO PAINT PLANTS			
ID,MT,NV	X,VIII,IX				
NM,UT	VI,VIII	156	38	5	.3
IL	V	5609	1376	193	9.9
IN	V	694	170	24	1.2
IA	VII	714	175	25	1.3
KS,NB	VII	132	32	5	.2
KY	IV	2954	725	101	5.2
LA	VI	SEE ARKANSAS			
ME,NH,VT	I	59	14	2	.1
MD	III	1247	306	43	2.2
MA	I	733	180	25	1.3
MI	V	2900	712	100	5.1
MN	V	533	131	18	.9
MS	IV	SEE ALABAMA			
MO	VII	2142	526	74	3.8
MT	VIII	SEE IDAHO			
NB	VII	SEE KANSAS			
NV	IX	SEE IDAHO			
NH	I	SEE MAINE			
NJ	II	4690	1151	161	8.2
NM	VI	SEE IDAHO			
NY	II	2435	598	84	4.3
NC	IV	1100	270	38	1.9
ND	VIII	NO PAINT PLANTS			
OH	V	4230	1038	145	7.4
OK	VI	SEE ARKANSAS			
OR	X	SEE ALASKA			
PA	III	2734	671	94	4.6
RI	I	78	19	3	.1
SC	IV	SEE DELAWARE			
SD	VIII	NO PAINT PLANTS			
TN	IV	450	110	15	.8
TX	VI	2675	656	92	4.7
UT	VIII	SEE IDAHO			
VT	I	SEE MAINE			
VA	III	479	118	16	.8
WA	X	381	94	13	.7
WV	III	SEE DELAWARE			
WI	V	577	142	20	1.0
WY	VIII	NO PAINT PLANTS			
NATIONAL		48906	12001	1679	85.9

---

*To convert data to tons/yr, multiply by 1.1.

**Note: Net Weight = Dry Weight

TABLE 63

QUANTITIES OF WASTES FROM MANUFACTURE OF
PUTTY & MISCELLANEOUS PAINT PRODUCTS BY STATE - 1983
SIC 28518 & 28519
kkg/yr*
(Wet Weight)**

STATE	EPA REGION	TOTAL WASTE	POTENTIALLY HAZARDOUS WASTE STREAM	HAZARDOUS SOLVENTS IN WASTE	TOXIC CHEMICAL COMPOUNDS IN WASTE
AL,MS	IV	764	187	20	1.2
AK,OR	X	361	89	10	.6
AZ	IX	125	31	3	.2
AR,LA,OK	VI	521	128	14	.8
CA	IX	10094	2470	269	16.1
CO	VIII	500	123	13	.8
CT	I	118	29	3	.2
DE,DC,WV,SC	III,IV	161	39	4	.3
DC	III	SEE DELAWARE			
FL	IV	1626	398	43	2.6
GA	IV	3725	912	99	5.9
HI	IX	NO PAINT PLANTS			
ID,MT,NV	X,VIII,IX				
NM,UT	VI,VIII	243	60	6	.4
IL	V	6721	1646	179	10.7
IN	V	834	204	22	1.3
IA	VII	1105	271	30	1.8
KS,NB	VII	209	51	6	.3
KY	IV	5935	1454	159	9.5
LA	VI	SEE ARKANSAS			
ME,NH,VT	I	63	15	2	.1
MD	III	2266	555	61	3.6
MA	I	827	203	22	1.3
MI	V	3232	791	86	5.2
MN	V	827	203	22	1.3
MS	IV	SEE ALABAMA			
MO	VII	3315	812	89	5.3
MT	VIII	SEE IDAHO			
NB	VII	SEE KANSAS			
NV	IX	SEE IDAHO			
NH	I	SEE MAINE			
NJ	II	5775	1414	154	9.2
NM	VI	SEE IDAHO			
NY	II	3002	735	80	4.6
NC	IV	2002	490	53	3.2
ND	VIII	NO PAINT PLANTS			
OH	V	5067	1241	135	6.1
OK	VI	SEE ARKANSAS			
OR	X	SEE ALASKA			
PA	III	3371	825	90	5.4
RI	I	91	22	2	.1
SC	IV	SEE DELAWARE			
SD	VIII	NO PAINT PLANTS			
TN	IV	903	221	24	1.4
TX	VI	3579	877	96	5.7
UT	VIII	SEE IDAHO			
VT	I	SEE MAINE			
VA	III	869	213	23	1.4
WA	X	577	141	15	.9
WV	III	SEE DELAWARE			
WI	V	686	168	18	1.1
WY	VIII	NO PAINT PLANTS			
NATIONAL		69518	17018	1852	110.8

---

*To convert data to tons/yr, multiply by 1.1.
**Note: Wet Weight [illegible] Dry Weight.

TABLE 64

QUANTITIES OF WASTES FROM MANUFACTURE OF PUTTY AND MISCELLANEOUS PAINT PRODUCTS BY EPA REGION - 1977 & 1983
SIC 28518 & 28519
kkg/yr (tons/yr)
(Wet Weight)*

1977 EPA Region	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
I	978(1,078)	239(263)	34(37)	1.7(1.9)
II	7,125(7,838)	1,749(1,932)	245(270)	12.5(13.8)
III	4,548(5,014)	1,116(1,230)	156(172)	8.0(8.8)
IV	7,922(8,734)	1,944(2,143)	272(300)	13.9(15.3)
V	14,543(15,997)	3,569(3,926)	500(550)	25.5(28.0)
VI	3,081(3,397)	756(834)	106(117)	5.4(6.0)
VII	2,988(3,287)	733(806)	104(114)	5.3(5.8)
VIII	293(323)	72(79)	10(11)	0.5(0.6)
IX	6,748(7,440)	1,656(1,826)	232(256)	11.9(13.1)
X	636(701)	156(172)	22(24)	1.1(1.2)
NATIONAL	48,862(53,800)	11,990(13,210)	1,681(1,852)	85.8(94.5)
1983				
I	1,098 1,208)	269(296)	29(32)	1.7(1.9)
II	8,777(9,655)	2,149(2,364)	234(258)	14.0(15.4)
III	6,602(7,279)	1,617(1,783)	176(194)	10.5(11.6)
IV	14,942(16,474)	3,659(4,034)	399(440)	23.9(26.4)
V	17,369(19,106)	4,253(4,678)	462(508)	27.7(30.5)
VI	4,170(4,598)	1,021(1,126)	111(122)	6.7(7.4)
VII	4,629(5,092)	1,134(1,247)	125(138)	7.4(8.2)
VIII	626(690)	153(169)	17(19)	1.0(1.1)
IX	10,286(11,341)	2,520(2,778)	275(303)	16.4(18.1)
X	973(1,073)	238(262)	26(29)	1.5(1.1)
NATIONAL	69,472(76,516)	17,013(18,737)	1,854(2,042)	110.8(122.1)

*Note: Wet Weight = Dry Weight

The projected national distribution of putty and miscellaneous paint products by waste stream in 1977 and 1983 is shown in Table 65. Projected production growth and waste data of surveyed plants were used in these extrapolations.

Summary

Total current wastes from the paint industry are estimated to be 389,000 kkg (428,000 tons) per year. Sixty-seven percent or 262,000 kkg (288,000 tons) of this waste contains no hazardous constituents. It consists of wooden skids and crates, wrapping paper, steel strapping, damaged cans, etc.

Of the remaining 127,000 kkg (140,000 tons), 96,000 kkg (106,000 tons) are potentially hazardous wastes because they contain solvents which are flammable and/or toxic or toxic metallic compounds. The 31,000 kkg (34,000 tons) difference between these numbers is accounted for by the weight of raw materials bags which contain innocuous substances which in current practice are mixed with bags containing a residual of potentially hazardous materials.

Total potentially hazardous wastes contain about 14,300 kkg (15,700 tons) of hazardous solvents and 841 kkg (925 tons) of toxic metallic compounds or a total of about 15,100 kkg (15,600 tons) of hazardous constituents contributed by five sources. A total of 82,000 kkg (90,000 tons) of wastes derive from the cleaning of process equipment. They contain 13,600 kkg (15,000 tons) of hazardous solvents and 590 kkg (650 tons) of toxic metallic compounds. A total of 32,800 kkg (36,100 tons) of waste raw materials bags contain 2000 kkg (2200 tons) of bags containing 130 kkg (140 tons) of toxic metallic compounds.

Dust collected in air pollution abatement equipment amounts to 1600 kkg (1700 tons) and contains 80 kkg (90 tons) of toxic metallic compounds. The total 4900 kkg (5400 tons) of spoiled batches discarded each year is estimated to contain 580 kkg (600 tons) of hazardous solvents and 41 kkg (45 tons) of toxic metallic compounds.

Total spilled material along with absorbent materials used for clean-up amounts to 5400 kkg (6000 tons) annually. This includes 85 kkg (94 tons) of hazardous solvents and 5 kkg (5 tons) of toxic metallic compounds.

Since potentially hazardous wastes are not segregated from non-hazardous materials in current sold waste handling, the total 15,100 kkg (16,600 tons) of hazardous constituents are dispersed throughout the total 389,000 kkg (428,000 tons) of solid waste although they constitute less than four percent of it. Hazardous constituents are not, however, uniformly distributed and may constitute a higher percentage of the waste in some disposal sites.

TABLE 65

QUANTITIES OF WASTE STREAMS BY SOURCE - 1977 & 1983
PUTTY AND MISCELLANEOUS PRODUCTS
SIC 28518 & 28519
kkg/yr (tons/yr)
(Wet Weight)*

Waste Stream	Total Waste	Potentially Hazardous Waste Stream	Hazardous Solvents In Waste	Toxic Chemical Compounds In Waste
1977				
Cleanings	10,400(11,466)	10,400(11,466)	1,600(1,764)	60(66)
Raw Material Packaging	37,100(40,904)	200(221)	---	13(14)
Air Pollution Collection	200(221)	200(221)	---	8(9)
Spoiled Batches	500(551)	500(551)	70(77)	4(4)
Spills	700(772)	700(772)	10(11)	1(1)
TOTAL	48,900(53,914)	12,000(13,231)	1,680(1,852)	86(94)
1983				
Cleanings	14,800(16,318)	14,800(16,318)	1,770(1,951)	77(85)
Raw Material Packaging	52,750(58,159)	270(298)	---	17(19)
Air Pollution Collection	280(309)	280(309)	---	11(12)
Spoiled Batches	700(772)	700(772)	77(85)	5(6)
Spills	970(1,069)	970(1,069)	11(12)	1(1)
TOTAL	69,500(76,627)	17,020(18,766)	1,858(2,048)	111(123)

*Note: Wet Weight = Dry Weight

TREATMENT AND DISPOSAL TECHNOLOGY

Introduction

This section describes the practices utilized by the paint and coatings industry to dispose of its potentially hazardous wastes. The most prevalent, and almost universal, technology is off-site deposition in a landfill for raw materials packaging, spills, spoiled batches, and collected dust from air pollution abatement equipment. It is also the most widespread disposal method for drummed water and organic wash solvents although reclamation accounts for about 35 percent of the organic wastes and some wastewater sludges are disposed of in municipal sewers.

Very few paint companies control their own landfill operations and most contract for the disposal services of others. Only a limited amount of information on the characteristics and management of off-site land disposal sites utilized by the industry and its contractors was developed within the altered scope of this study as discussed in Section III. There are varying degrees of interest in and knowledge of the disposal contractor's practices at the paint plant. This resulted in the expression of a wide variety of nomenclature during plant surveys to describe what are probably most frequently sanitary landfills. This assumption can be made more confidently in those states or areas which no longer permit open dumping and require approval and inspection of landfill operations. No on-site visits of these operations were made.

Virtually no treatment of potentially hazardous wastes is employed by the paint industry for the reasons discussed below. Instead of treatment, a more opportune waste control measure in this industry appears to be elimination of potentially hazardous materials from the waste. This approach may follow several pathways in the future and is presently exemplified by reductions in the use of lead and mercury as raw materials, the production of increasing quantities of water-based products, and the accompanying reduction in solvent-based products.

Technology is indicated in this section for the disposal of each potentially hazardous waste stream by the paint industry. These are based on the most prevalent industry-wide practice (Level I); the best method presently used which is amenable to more widespread use (Level II); and the disposal practice deemed environmentally adequate to handle wastes from this industry (Level III).

As noted above, waste disposal practices in this industry do not differ significantly among the various SIC product codes. This is partly due to the fact that the same types of wastes are generated in the manufacture of trade sale paints, industrial coatings, lacquers, putty, and miscellaneous products. Another reason is that two or more of the above products are made in varying quantities in the great majority of paint plants and many of the waste streams are not separated by product.

[illegible] potentially [illegible] at all paint and coatings manufacturing [illegible] results from the manufacture of [illegible] except for [illegible] finished paint where waste [illegible] sludge [illegible]. In [illegible], both water-thinned and solvent-thinned paints are produced at a given plant-site so that both these types of wastes are generated within the same plants. [illegible] from air pollution control equipment is generated from among all the product codes as are spills and waste materials.

Thus, in this section excessive repetition is avoided by discussing the disposal practices for each waste stream which are equally applicable to each five-digit product category within SIC 285.

Description of Present Treatment Technologies

The reclamation of organic wash solvents is the primary treatment technology applied to potentially hazardous wastes of the paint industry. None of the 71 surveyed plants treat wastes destined for landfill by conventional physical, chemical, or biological means. In addition, a poll of the 20 largest paint manufacturers, representing roughly 55 percent of the industry's production, on this specific question revealed that no treatment processes are employed at any of their plants except for wastewater sedimentation in some cases.

The only plant reporting a chemical treatment of any sort jells its waste products with an incompatible material such as caustic soda. The purpose of this is to prevent leakage in the event of drum damage in a landfill.

One reason for the lack of treatment is the relatively small amount of such wastes generated at individual plant sites. As discussed previously, it has been reasonably well established that only an average of about 30-60 gm (2 oz) of pigments, extenders, and other solids used by a manufacturer remain in the paint bags in which they were delivered at the time of disposal. Dusts of solids collected by air pollution control equipment (filters) amount to only about 0.6 gm/liter (4.9 lbs/ gal.) of paint and are sometimes put back in the process. The amount of sludges resulting from wastewater sedimentation which find their way to land disposal are [illegible] to the quantities put into municipal sewer systems or, in a few instances, a septic system. In addition, they are usually very low in potentially hazardous materials since few are used in water-thinned products.

The amounts of waste products, including spills, generated are also small in quantity. The total spills for one year reported by 57 surveyed plants [illegible] liters ([illegible] gal.), [illegible] just [illegible] liters ([illegible]) [illegible] per plant. Some of these [illegible] ([illegible] gal.) and others [illegible] work as much as possible, landfilling in drums only the rags or other materials used for final clean-up. Many paint plants today do not have floor drains into which spills might be lost. Newer manufacturing plants are designed without them, and in some older plants existing drains have been blocked off.

Spoiled batches are also a rarity in some plants and where they occur reworking into the process is common practice. The quantities of hazardous materials from this source drummed and placed in a landfill are further reduced by two factors:

1. Factory-applied coatings, which account for the majority of spoiled batches unsuitable for reworking, frequently contain little or no drier.

2. The high price of significant amounts of toxic metals enhances the probability that paints containing them will be reworked.

Small batch samples, 0.5 or 1 liter (1 or 2 pints) per batch, are usually crushed and disposed of periodically in drums, as are some products for which the shelf-life has expired. These, too, are nearly always in small containers since it is economic to open and rework larger containers of paint.

Solvent recovery and reuse are reducing the quantities of waste wash solvent discarded and if the price of fresh solvent continues to rise, this practice will no doubt become more widespread. Approximately 21 of the surveyed plants send some or all of their used wash solvents to off-site distillers. In many cases, the reclaimed material is returned to the originating plant. These operations are discussed in more detail in a subsequent section of this report.

Five surveyed plants indicated that solvents are recovered on-site for reuse, but the evidence is that only two of them actually employ a still for this purpose. Assuming that the other three simply settle and decant their used solvents, there is a total of nine which report use of this practice. Six others reuse solvents in lower grade or other products without treatment.

One viable alternative to treatment is a reduction in the quantity of potentially hazardous materials used in manufacture. The most popular approach now, and in the future according to company spokesmen, is increased production of water-thinned paints to replace all or a substantial proportion of solvent-thinned products. Progress is also evidenced in replacements for lead and mercury compounds as well as a shift from coal tar to petroleum-based solvents. There is presently, however, a limitation to this approach insofar as certain ingredients are concerned -- i.e., some compounds are irreplaceable in the uses to which they are put, such as lead chromate and copper phthalocyanine, as discussed earlier.

Another possibility in the reduction of the quantity of potentially hazardous materials is a more thorough job of removing traces of pigments and other potentially hazardous raw materials from the containers in which they were delivered. Although this is unlikely to be achieved 100 percent, it is already being done by some with existing packaging to the limit which will satisfy Occupational Safety and Health Act and other health-related regulations. Improvements in container design to facilitate emptying is another alternative, albeit one which is outside the scope of this project.

Description of Present Disposal Technology.

Paint plants do not, by and large, segregate potentially hazardous materials for storage and disposal, and there is little appreciable difference in the disposal practices employed for each category of potentially hazardous wastes. The major exception is organic solvent, some of which is segregated for reclamation and some for the reasons suggested below.

The balance of the spent solvent -- all of it in some plants -- is drummed for disposal and deposited in a waste storage container, typically a Dumpster. Product waste which cannot be reworked, wastewater sludges, and unusable solids recovered from air filters are also drummed and stored in the same container, which also holds the raw materials containers. (Only one plant reported using a separate container for bags which had contained potentially hazardous materials.)

The segregation which occurs in waste handling is generally according to the physical nature of the waste -- solid, semi-solid, or liquid -- and is undertaken in most instances more as a matter of convenience in sorting and disposing of these various materials rather than as an environmental benefit. Only three of the 15 plants which indicated waste segregation ascribed their motivation to "special care in handling" of potentially hazardous wastes, two said it was to permit recovery of hazardous wastes, and the balance drum them separately for various reasons. These include separate pick-up of some materials by different contractors from those hauling trash, which apparently is increasing due to the fact that some land disposal operations will not accept solvents or paint wastes.

When the refuse collection receptacle is full, or at certain specified intervals, it is emptied, usually by a contractor, and the contents dumped into some type of land disposal site. There are, as yet, few exceptions to this procedure.

This conclusion is based on the fact that some part or all of the potentially hazardous wastes of at least 51, or 76 percent, of 67 surveyed plants are deposited in a landfill. If the wastes of the 12 which claim no knowledge of the method used by contractors or municipal trash collectors for disposition are added, then the proportion rises to 94 percent. This may be slightly weighted toward direct land disposal since the wastes of some may be incinerated. This is not considered to be a significant factor, however, because of those who could identify the disposal method only three indicated off-site disposal in private or municipal incinerators.

As noted in the introduction to this section, the information elicited during the paint plant surveys concerning the type of public or private landfill where their wastes are deposited is sketchy. The plant representatives interviewed who claimed no knowledge of the ultimate fate of the wastes collected by a contractor are no doubt a carry-back to a not too distant period when not knowing was considered at least in part a legal defense in case of liability incurred. Today, while the line of responsibility is not always clear cut, most plant operators do ascertain that the resting place of their discarded materials meets existing regulations. However, probably because imposition of standards is relatively new, the meaning of waste disposal terminology grows cloudy.

The use of the words "dump" and "landfill" in some cases appears almost certainly to reflect semantics rather than differences in practices employed at a land disposal site. The term "dump" is, of course, self-explanatory and describes a type of disposal area which is no longer permitted in many jurisdictions of the United States. "Landfill" was understood to mean sanitary landfill, or land disposal facility in which mixed wastes are compacted in layers and covered with soil daily. The two terms were used interchangably by some industry spokesmen encountered during the survey, and, while an effort was made to obtain elaboration on the characteristics of the disposal site, this information is unfortunatly in some instances not as precise as it might be. However, at least six plants referred only to a "dump" as their contractor disposal site with no qualification to indicate otherwise. Where terminology such as "taken to the city dump and buried" was employed, the practice was assumed to refer to a sanitary landfill.

None of the surveyed plants reported utilizing special owned landfills for potentially hazardous wastes, and only two specifically reported use of a segregated landfill. On the other hand, one reported that its solid wastes go by truck to a "dump," but that the "dump" will not accept paint or solvents. Two or three others stated that their potentially "hazardous" wastes go to one landfill and their paper and trash to another, also indicating some degree of segregation by landfill operators. However, it appears that the differentiation is actually only between semi-solid and liquid wastes, such as sludges and used solvents, and solid wastes rather than between hazardous and non-hazardous materials since the former would include residual amounts of pigments and other solids remaining in the paper bags.

Of the 51 plants specifically signifying the use of land disposal, 15 indicated that their wastes go to municipal or county landfills. Others identified private landfills, and still others did not specify. On the basis of similar responses by other interviewees and the known practices of hauling contractors in some cases, it is estimated that the bulk of the remaining 36 go to private landfill. There is some evidence that on limited occasions rubbish haulers contract to dispose at one site and find it more economical to use another.

Waste disposition at the surveyed plants is overwhelmingly performed by contractors. Less than one in 10 indicated exclusive use of their own trucks for hauling to a landfill.

One off-site disposal contractor employs sanitary landfill and incineration along with deep well disposal. This was the only reported use of the latter disposal technology; no paint plants have deep disposal wells on-site (34). Only one surveyed plant sells waste paper for recycling, a practice which is sharply inhibited by the presence of pigments in packaging materials.

Only two surveyed plants reported the use of on-site landfill. However, the percentage represented by this number may be low for plants located away from metropolitan areas who have available land.

Incineration is not commonly used to dispose of the organic wastes of the paint industry. Only three surveyed plants reported the use of on-site incinerators, and indications are that one of these is used exclusively for paper and other trash. Thus, two operate units for burning spoiled batches, used solvents, or solvent reclamation still bottoms. Only one other on-site incinerator is known to exist in the paint industry for disposal of these types of wastes.

There are several reasons generally cited by the industry to explain why the use of incineration is limited. These include:

1. Organic waste accumulation rates for a given plant are too small to justify an incinerator.

2. Most incinerators cannot satisfactorily handle the viscuous and solids-bearing wastes generated in paint plants.

3. Incinerators can require substantial operator attention and maintenance.

4. Air pollution abatement equipment, requiring further capital and operating and maintenance costs, must generally be provided.

5. Incinerator noise levels and space requirements can be a problem, since most manufacturing facilities are located in urban areas.

A few paint manufacturers have installed special types of incinerators in an attempt to circumvent some of these problems. In general, each plant site having an incinerator generates sufficient organic wastes to justify an on-site incineration system, and each is located outside an urban area where noise and space requirements are not significant problems.

No conventional, municipal refuse type incineration systems are in use to dispose of organic wastes in this industry to the contractor's knowledge. Two of the facilities which have been installed to date for this purpose are called "open-pit" incinerators. Only one of these units is currently in operation. An open-pit incinerator (sometimes referred to as a trench incinerator) consists of a refractory-lined open trench to which combustion air is blown through numerous nozzles positioned to provide turbulence, yet confine combustion to the trench itself.

One paint manufacturer has recently installed a prototype, yet commercial-scale, rotating hearth incinerator. This unit is used to burn still bottoms from the plant's tank cleaning solvent reclaiming facilities. This incinerator consists of a cylindrical combustion chamber with stack (no emission control devices), a circular rotating hearth, and an external ash collection system. Still bottoms are dropped at a controlled rate onto the hearth and rotated directly into the combustion chamber. Due to a lack of turbulence at the hearth level, the waste material volatilizes or burns directly on the hearth with little ash becoming entrained into the combustion gases. No auxiliary fuel is required during steady-state operation. One of the unique features of the unit's operation is its relatively low noise level.

Off-site incineration may become an increasingly viable disposal alternative as communities and larger disposal service companies adopt this means. This is especially true in the case of flammable solvents which, more and more, are being refused by sanitary landfills. Incinerators capable of handling these materials are available and in use. Properly equipped with scrubbers and any other air pollution controls necessary to meet state or local regulations they represent an attractive solution for the disposal of low-flash solvents.

A technique with potential for reducing or eliminating potentially hazardous wastes involves incorporating spoiled batches, spills, and other product wastes into saleable materials such as lower grade products. This is already extensively practiced within most plants. However, the benefits could be expanded in cases where this is not feasible or economic in the originating plant through standing arrangements in which a manufacturer of a different line of coatings products would routinely accept and rework such material. This is also true of solids collected by air pollution control equipment.

On-Site vs. Off-Site Disposal

Only three of 67 surveyed plants acknowledged some on-site disposal. Only one of these disposes of all of its wastes on-site, employing incineration for solid, trash-type waste only. Other materials are reused. Two utilize sites both on and off the premises. One of these uses on-site landfill and incineration; the other landfill only. It is possible that the incidence of on-site disposal is higher among plants located in less populated areas where land is more accessible although this is counterbalanced by the fact that the largest numbers of plants are located in metropolitan areas. Table 66 shows an estimate of the number of plants practicing on-site disposal and off-site disposal of each potentially hazardous waste stream. Following from the site visits, the vast majority of plants use off-site disposal practices.

There was no indication that any of the plants surveyed plan to change their disposal mode with regard to on-site or off-site location in the foreseeable future. Thus, no significant increase in on-site disposal practices, either using incineration or landfills, is expected through 1983.

Safeguards Used in Disposal

At each of the plants surveyed the question was asked: Are potentially hazardous wastes handled or treated differently from other solid or semi-solid wastes? Forty-six plants indicated that there is no difference in handling. Of the 15 who state that they drum potentially hazardous wastes separately, only two indicated that this is the result of a desire for special care in handling. Two others noted that normal safety precautions -- masks, gloves, etc. -- are used in handling solvents. For the most part, the separate drumming can be attributed to the segregation of solvents for recovery. The "different" treatment accorded potentially hazardous wastes consisted of burning in two cases and recovery in two. In only one instance was the use of a separate container for bags which had contained hazardous material recorded. In one other, drums of wastes containing asbestos were so marked. As pointed out above, one utilizes incompatible materials to jell product wastes to eliminate leakage from broken drums in the landfill. On the basis of information in hand, it is not possible to establish the norm or the average of safeguards employed at off-site waste disposal sites currently in use.

Private Contractors and Service Organizations

Only ten surveyed plants haul all or part of their wastes to disposal, with seven handling all of it themselves. Thus, the private contractors or, in a handful of cases, municipal trash collection and disposal systems, are the actual depositors or reclaimers of the wastes

TABLE 66

COMPARISON OF CURRENT ON-SITE AND OFF-SITE DISPOSAL PRACTICES

	Estimated Number of Plants Practicing	
	On-Site Disposal	Off-Site Disposal
Raw Materials Packaging Wastes		
Landfill(1)	70	1470
Incineration	5	50
Wastewater Sludge		
Landfill(1)	50	1070
Incineration	0	0
Spills and Spoiled Batches		
Landfill(1)	70	1470
Incineration	0	0
Waste Organic Cleaning Solvent		
Landfill(1)	50	950
Incineration	5	20
Dust from Air Pollution Abatement Equipment		
Landfill(1)	50	950
Incineration	0	0

---

(1) Landfill may consist of open dump, sanitary landfill, or secured landfill.

of 85 percent of these plants. As noted above, due to the contract redirection, complete descriptions of the types of disposal practices of these contractors are not available. A list of those utilized by surveyed plants is shown in Appendix F. There will be some crossover between this list and the solvent reclaiming operations introduced in another portion of this report.

Levels of Treatment and Disposal Technology for Potentially Hazardous Waste Streams

The U.S. Environmental Protection Agency has defined three levels of treatment and disposal technology which are or may be applicable to potentially hazardous waste streams generated by the paint and coatings industry which are destined for land disposal. These technology levels are defined as follows:

Level I - The technology currently employed by typical facilities -- i.e., broad average present treatment and disposal practice.

Level II - The best technology currently employed. Identified technology at this level must represent the soundest process from an environmental and health standpoint currently in use in at least one location. Installations must be commercial scale; pilot and bench scale installations are not suitable.

Level III - The technology necessary to provide adequate health and environmental protection. Level III technology may be more or less sophisticated or may be identical with Level I or Level II technology. At this level, identified technology may include pilot or bench scale processes providing the exact stage of development is identified.

Different treatment and disposal technologies were identified for each of five waste streams of this industry. The technologies, however, are identical for these waste streams of all SIC subcategories of paint and coatings manufacture covered by SIC 285 and are applicable to all of them.

Somewhat different groupings are represented in these streams from the arrangements necessarily used in describing waste quantities. In the earlier discussions, spills and spoiled batches were treated separately because the latter is finished product only and spill wastes contain some amount of absorbent clean-up material. However, treatment and disposal are identical for these wastes and they are dealt with jointly. Conversely, in the section on waste quantities, water and organic solvent cleaning wastes were grouped together because the data available were insufficient to quantify each of these wastes as separate streams. However, there are differences in Levels II and III treatment and disposal technologies for these wastes so they are separated for this purpose.

The percentage of plants using each technology was estimated on the basis of survey data from 67 plants. This sample of establishments represents approximately 4.3 percent of the industry's production.

Implicit in disposal technologies identified is off-site practice. This is not to preclude on site operations but recognizes the economic and space limitations peculiar to many plants in this industry.

Definitions which apply to the technologies are as follows:

Landfill - Land disposal facilities characterized by their acceptance of a wide variety of wastes including garbage which are compacted in layers and covered daily. They do not normally have special containment, monitoring, or provision for treatment of leachate.

Secured Landfill - Land disposal facilities characterized by impervious containment of the waste with provisions for monitoring and treatment of leachate if required. Adequate diversion and control of surface water are required as well as registration of the site for a permanent record of its location once filled.

Incineration - Combustion of an organic or partially organic waste stream with adequate means for complying with applicable air pollution control regulations and for disposal of collected particulate and ash (usually of a potentially hazardous nature) in a secured landfill.

The most prevalent current technology (Level I) for raw materials packaging is off-site landfill. It is practiced by probably 90 percent of the industry. This is also the best technology currently in use (Level II) for this waste stream, although environmentally adequate technology (Level III) will require segregation and incineration of bags containing hazardous materials with the ash sent to a secured landfill. These technologies and pertinent considerations are summarized in Table 66. It will be remembered that the treatment and disposal technology is applicable to a potentially hazardous waste stream which, in the case of raw materials packaging, is only a fraction of the total stream. The balance consists of innocuous packaging described previously.

Tables 67 through 71 show that off-site landfill is also Level I technology for the disposal of waste products including spills and spoiled batches, wastewater sludge, organic cleaning solvent, and dust from air pollution abatement equipment. It is practiced by virtually 100 percent of the plants for disposal of waste products; by 60 percent for wastewater sludge and organic solvents, and 80 percent for collected dusts. It is also Level II technology for waste product disposal.

TABLE 67

RAW MATERIALS PACKAGING WASTE DISPOSAL

FACTOR	LEVEL I (Prevalent Technology)	LEVEL II (Best Technology Currently Employed)	LEVEL III (Technology for Adequate Health and Environmental Protection)
Physical & Chemical Properties of Residual Wastes	90% kraft paper, 6% pigment - some of which is hazardous	Same as Level I	Metal oxide ash - some of which is hazardous
Description of Residual Waste	Loose or compacted solid materials	Same as Level I	Dust
Factors Affecting Degree of Hazard	Pigments with heavy metal salts which are toxic	Same as Level I	Same as Level I
Treatment/Disposal Technology	Off-site landfill	Same as Level I	Segregation & incineration of bags containing hazardous materials. Ash to secured landfill
Estimated Number of Plants Using Technology	1470	Same as Level I	0
Adequacy of Technology	Inadequate, leaching of metal salts may occur, contaminating ground-water or surface water*	Same as Level I	Adequate, assuming proper collection of particulates from incinerator
Problems and Comments	Most inexpensive disposal method and readily available	Same as Level I	Insufficient number of incinerators available
Non-land Environmental Impact	Possible leachate runoff and ground-water contamination problems	Same as Level I	Air pollution control on incinerator must be adequate to meet adequate regs.
Compatibility with Existing Facilities	Easily compatible. Need only trash collection receptacle, hauler, and off-site landfill	Same as Level I	Changes required in waste handling methods to include segregation. Incinerator, if located on-site must be safe distance from solvent storage and production areas
Monitoring and Surveillance Techniques	None	Same as Level I	Air pollution monitoring of incinerator. Leachate and runoff in landfill
Installation Time	None	Same as Level I	Incinerator & availability of secured landfill 1-3 years
Energy Requirements	For compacting (if any) hauling waste to landfill, and covering waste	Same as Level I	Possibly for hauling waste to off-site incinerator. May gain waste heat from incineration. Should only need supplemental incinerator fuel during startup and shutdown

---

*Possibly toxic to landfill microbes.

TABLE 68

DISPOSAL OF WASTE PRODUCTS INCLUDING SPILLS AND SPOILED BATCHES

FACTOR	LEVEL I (Prevalent Technology)	LEVEL II (Best Technology Currently Employed)	LEVEL III (Technology for Adequate Health and Environmental Protection)
Physical & Chemical Properties of Residual Wastes	Mixture of pigment, resin, solvent, and possibly small concentrations of additives. Some pigments, solvents, and/or additives may be hazardous	Same as Level I	Incinerated ash consisting mainly of pigments - some of which are hazardous
Description of Residual Waste	Viscuous liquid	Same as Level I	Dust
Factors Affecting Degree of Hazard	Pigments of heavy metal salts and additives may be toxic. Solvents may be flammable.	Same as Level I	Dust contains pigments and additives which may be toxic
Treatment/Disposal Technology	Off-site landfill	Same as Level I	Incineration with ash to secured landfill
Estimated Number of Plants Using Technology	1470	Same as Level I	0
Adequacy of Technology	Inadequate. Leaching of heavy metal pigment salts may occur contaminating groundwater or surface water*	Same as Level I	Adequate, assuming proper collection of particulates from incineration
Problems & Comments	Most inexpensive disposal method and readily available	Same as Level I	Insufficient number of incinerators available
Non-land Environmental Impact	Possible leachate & runoff problems	Same as Level I	Air pollution control on incinerator must be adequate to meet applicable regs.
Compatibility with Existing Facilities	Easily compatible. Need only trash collection receptacle, hauler, and off-site landfill	Same as Level I	Incinerator, if located on-site must be safe distance from solvent storage and production areas
Monitoring and Surveillance Techniques	None	Same as Level I	Leachate, runoff, and air pollution control monitoring
Installation Time	None	Same as Level I	Incinerator and availability of secured landfill 1-3 years
Energy Requirements	For hauling waste to disposal site and covering with fill	Same as Level I	Same as Level I, plus supplemental fuel for incinerator startup and shutdown

---

*Possibly toxic to landfill microbes.

TABLE 69

WASTEWATER SLUDGE DISPOSAL

FACTOR	LEVEL I (Prevalent Technology)	LEVEL II (Best Technology Currently Employed)	LEVEL III (Technology for Adequate Health and Environmental Protection)
Physical & Chemical Properties of Residual Wastes	Sludges with 3-10% total solids which principally consist of pigments some of which contain heavy metal salts which are hazardous, and resins	Same as Level I, but with higher solids content	Sludge cake of at least 20% total solids which consist of pigments, some of which contain heavy metal salts which are hazardous, and resins
Description of Residual Wastes	Pigmented liquid	Same as Level I but more viscuous	Semi-solid material
Factors Affecting Degree of Hazard	Varying quantities of pigments with heavy metal salts which are toxic	Same as Level I	Same as Level I
Treatment/Disposal Technology	Off-site landfill	Sludge settled and sent to landfill	Chemical settling and dewatering of sludge followed by secured landfill
Estimated Number of Plants Using Technology	800	270	0
Adequacy of Technology	Inadequate leaching of heavy metal pigment salts may occur contaminating groundwater or surface water*	Same as Level I	Adequate to protect health and environment,assuming proper operation
Problems & Comments	Most inexpensive disposal method and readily available	Sludge settling equipment is uncomplicated and requies little space	Dewatering equipment availability may be a problem
Non-land Environmental Impact	Possible leachate & runoff problem	Same as Level I	No adverse impact
Compatibility with Existing Facilities	Easily compatible. Only need drum storage facilities	Need sedimentation equipment which is widely available	No compatibility problems
Monitoring and Surveillance Techniques	None	Same as Level I	Leachate and runoff monitoring in landfill.
Installation Time	None	Settling facility for treatment 6 months to 2 years	Dewatering equipment could take 1-3 years for delivery and installation
Energy Requirements	For hauling waste to disposal site and covering with fill	Same as Level I, plus pumping wastes to and from settling equipment	Same as Level I, plus pumping wastes to dewatering equipment

---

*Possibly toxic to landfill microbes.

TABLE 70

ORGANIC CLEANING SOLVENT WASTE DISPOSAL

FACTOR	LEVEL I (Prevalent Technology)	LEVEL II (Best Technology Currently Employed)	LEVEL III (Technology for Adequate Health and Environmental Protection)
Physical & Chemical Properties of Residual Wastes	Dirty solvent containing organic sludge and pigments, some of which are heavy metal salts which are hazardous	Ash consisting of pigments, some of which are heavy metal salts which are hazardous	Same as Level II
Description of Residual Wastes	Liquid usually stored in drums	Dust	Same as Level II
Factors Affecting Degree of Hazard	Waste solvent could be flammable. Pigments with heavy metal salts may be toxic	Dust may contain heavy metal salts which could be toxic	Same as Level II
Treatment/Disposal Technology	Off-site landfill	Solvent reprocessing with still bottoms incineration followed by landfill disposal of ash	Level II with ash to secured landfill
Estimated Number of Plants Using Technology	950	50	0
Adequacy of Technology	Inadequate leaching of heavy metal pigment salts may occur, contaminating groundwater or surface water.*	Same as Level I	Adequate assuming proper collection of particulates from incinerator
Problem & Comments	Most inexpensive disposal method and readily available	Solvent recovery is usually cost-effective	Insufficient number of incinerators available
Non-land Environmental Impact	Possible leachate & runoff problems	Same as Level I plus possible air pollution from still bottoms incinerator	Air polluton control on incinerators must be adequate to meet applicable regulations
Compatibility with Existing Facilities	Easily compatible. Need only trash collection receptable, hauler, and off-site landfill	Processing usually more economical off-site	Same as Level II
Monitoring and Surveillance Techniques	None	Same as Level I	Leachate & air pollution monitoring
Installation Time	None	1-3 years for still & incinerator	Same as Level II
Energy Requirements	For hauling waste to disposal site and covering with fill	Waste hauling plus solvent reclaiming heat source, coolant, pumps, plus supplemental fuel for incinerator startup and shutdown	Same as Level II

---

*Possibly toxic to landfill microbes.

TABLE 71

DISPOSAL OF DUST FROM AIR POLLUTION ABATEMENT EQUIPMENT

FACTOR	LEVEL I (Prevalent Technology)	LEVEL II (Best Technology Currently Employed)	LEVEL III (Technology for Adequate Health and Environmental Protection)
Physical & Chemical Properties of Residual Wastes	Pigments - principally TiO_2 & $CaCO_3$, but can contain toxic heavy metal salts	Same as Level I	Same as Level I
Description of Residual Waste	Dry powder of small particle size	Same as Level I	Same as Level I
Factors Affecting Degree of Hazard	Varying portions of pigments which are toxic heavy metal salts	Waste is eliminated	A. Same as Level II B. Same as Level I
Treatment/Disposal Technology	Off-site landfill	Recycle into lower grade product	A. Same as Level II B. Off-site secured landfill
Estimated Number of Plants Using Technology	950	200	A. Same as Level II B. 0
Adequacy of Technology	Inadequate because runoff or leaching may occur*	Only applicable in plants where product specs. permit use	A. Same as Level II B. Adequate assuming proper landfill operation
Problems & Comments	Dust can be local air pollution hazard at landfill site if not immediately covered	Not technically possible in all plants due to product quality specifications	A. Same as Level II B. Same as Level I
Non-land Environmental Impact	Possible leachate and runoff problems	None	A. Same as Level II B. Same as Level II assuming proper operation of the landfill
Compatibility with Existing Facilities	Easily compatible. Need only trash collection receptacle or drums, hauler and off-site landfill.	Many plants do not have suitable products for incorporation of this material	A. Same as Level II B. Availability of secured landfill
Monitoring & Surveillance Technique	None	None	A. Same as Level II B. Leachate & runoff monitoring
Installation Time	None	Formulation & product reorganization 0-5 years	A. Same as Level II B. Availability of secured landfill 1-3 years.
Energy Requirements	For hauling waste to disposal site and covering with fill.	None	A. Same as Level II B. Same as Level I

---

*Possibly toxic to landfill microbes.

As an example, if a "typical" large paint manufacturing facility is defined as an operation producing a variety of water-thinned paints, solvent-thinned paints, lacquers, factory-applied coating, and some miscellaneous paint products, all the various process waste streams from such a plant would be combined in trash receptacles. These wastes would be picked up by a private hauler up to several times per week and taken off-site to a public or private sanitary landfill.

Level II technology for wastewater sludge is sludge settling and disposal in a landfill, which is currently practiced by about 20 percent of the plants; for organic solvents, reprocessing with incineration of still bottoms followed by landfill disposal of ash, 35 percent; and collected dust, recycling into a lower grade product, 15 percent.

Level III technology for waste products is incineration with ash deposition in a secured landfill. Chemical settling and sludge dewatering followed by a secured landfill is Level III for disposal of wastewater sludges. Level III for organic solvents is the same as Level II except that a requirement for a secured landfill is added. Level III for collected dusts offers the alternatives of use in low grade products or deposit in a secured landfill. So far as is known no plants presently practice any of the Level III technologies.

The data and conclusions contained in Tables 67 through 71 are for the most part self-explanatory. However, it should be noted that residual wastes deposited in land include, where applicable, ash from incineration of wastes.

Also, the footnote on each table pointing up the potential of paint wastes for toxicity to microbes in landfills relates primarily to wastes associated with water-thinned paints. This is not a major problem with the insoluble toxic heavy metals, but mercury, which is water-soluble, can be very troublesome. Its source is largely phenyl mercuric acetate used in water-thinned materials.

The conclusions are the contractor's best assessment of the current situation based on very general information. As discussed previously, when the contract was redirected to include processes other than paint manufacture, the major focus of the original contract curtailed was the study of disposal technologies. However, the lack of an in-depth study in this particular area does not appear to be especially detrimental in view of the uniformity of paint industry technology and the detailed information EPA is otherwise developing on specific land disposal practices.

The one feature of Tables 67 through 71 which may reflect the reduced scope of investigation in this area is Level III technology. It may be unduly restrictive in some cases but this was felt necessary since the environmental adequacy of any lesser technologies was not verified. The need for and relative cost/benefit of these requirements will be clarified to a large extent as more data on the behavior of these materials on land are accumulated.

COST ANALYSIS

Introduction

The cost analysis section is organized according to the three levels of technology. Level I technology for the five potentially hazardous waste streams of the paint and coatings industry is discussed first, and is followed by an analysis of Level II, and finally Level III. Costs are then summarized by waste stream.

Cost data on current waste disposal practices were sparse at most of the plants visited and much of the information collected is in the form of estimates by plant personnel. Nonetheless, it was necessary to use these data as the basis for the cost analysis of Level I and Level II technology because the effort originally apportioned to this phase of the program was reduced in order to perform studies in related industries. As a result, no significant data were collected from other sources such as hauling and disposal contractors. As a result of the rather small data base, cost figures have been rounded off to one significant figure.

Level III technology is generally not being implemented by the paint and coatings industry. Cost estimates for this technology as it applies to the various waste streams were developed from other EPA studies (35, 36, 37).

A key feature of the following cost analyses is that the costs given for each level of technology are based on off-site waste disposal. The reasons for this are as follows:

1. At least 90 percent of all paint manufacturers dispose of their wastes off-site.

2. The majority of existing paint plants are located in urban areas where space availability for treatment and disposal facilities on-site would be a major problem.

Treatment and Disposal Costs

Level I Technology

Level I technology is defined as the prevalent technology currently employed -- i.e., the broad average present treatment and disposal practice. The costs of disposing of each waste stream are as follows:

Raw Materials Packaging

Level I technology for raw materials packaging is off-site disposal in a landfill. Data from 25 surveyed plants show an average hauling and disposal cost of $20/kkg ($20/ton) of waste. The range of costs from these plants is $3-50/kkg ($3-50/ton). This wide cost range is probably due to the following factors:

1. Type of landfill in use.
2. Frequency of pick-up by the hauling contractor.
3. Volume of containers used for storage and pick-up.
4. Distance from plant to disposal site.
5. Cost variations in different regions of the country.
6. Accuracy of the estimated cost and waste stream volume.

Paint plant personnel generally did not know the breakdown between the hauling and landfill costs. Based on work by another EPA contractor (35), it is estimated that hauling costs will average $7/kkg ($6/ton). Thus, landfill costs to the paint companies are approximately $13/kkg ($12/ton) of the average total of $20/kkg ($18/ton) for both services. These landfill costs from plant survey data are considerably higher than the estimates commonly quoted in the literature -- $2-5/kkg ($2-5/ton).

These figures represent an average disposal of 310 kkg (340 tons) per year for the 25 plants. The range was 1 to 2210 kkg (1-2430 tons) per year.

Waste Solvents

Level I technology for waste organic wash solvent is also off-site disposal in drums in a landfill operation. Based on data from six surveyed plants, the average cost for hauling and disposal is $50/kkg ($50/ton) of waste solvent. The range is $14 to $140/kkg ($13-$130/ton). This wide range is probably due to the same factors listed above under raw materials packaging. It is estimated from work done by others (35) that hauling charges are $16 to $18/kkg ($15-16/ton). No costs were added to represent the loss of reclaimable solvent which would have to be replaced by fresh solvent.

Waste Water Sludge

Sludge from wastewater sedimentation is also generally drummed and hauled off-site to some type of landfill operation. This constitutes Level I technology, the costs for which are very similar to those for handling solvents.

The average cost for hauling and disposing of wastewater sludge is roughly $50/kkg ($50/ton). The range in six surveyed plants is $14 to $140/kkg ($13-$130/ton). The hauling portion of this cost is expected to run $16 to $18/kkg ($15-16/ton) depending on the distance traveled, the frequency of waste collection, the quantity transported per trip, and the types of other wastes carried.

Collected Dust From Air Pollution Abatement Equipment

Dust from bag collectors is normally sealed in 208-liter (55-gal.) drums and hauled away to an off-site landfill operation. This material is not shipped separately by any of the plants surveyed. Instead, the drummed dust is placed in a trash container and hauled away with loose solid waste including raw materials packaging.

For this reason, the cost of dust hauling and disposal has been compared with that of waste raw materials which is roughly $20/kkg ($20/ton). Since the cost of waste collection and disposal is normally based on volume rather than weight, the difference in densities of the two waste streams brings the average cost for dust hauling and disposal to approximately $6/kkg ($5/ton).

Waste Products and Spills

Level I technology for the disposal of waste products and spills consists of off-site landfilling. The cost of collection and disposal of these wastes from plant trash containers is based on volume and is thus the same as that of collected dust -- $6/kkg ($5/ton). Data were used from six survey plants which ranged from $2/kkg ($2/ton) to $16/kkg ($15/ton).

Level II Technology

Level II potentially hazardous waste disposal technology is defined as the best technology currently employed. Identified technology at this level must represent the soundest process from an environmental and health standpoint currently in use in at least one location. Installations must be commercial scale; pilot and bench scale installations are not suitable.

Raw Materials Packaging

Level II technology for this waste stream is equivalent to Level I. Based on information from surveyed plants, the average hauling and disposal cost is $20/kkg ($20/ton), of which approximately $7/kkg ($6/ton) is the hauling charge.

Waste Solvent

Level II technology for waste organic solvent consists of off-site solvent reprocessing with incineration of the still bottoms and disposal of the collected ash in a landfill operation. As noted previously, approximately one-third of the waste solvent generated by the paint and coatings industry is treated in this manner, primarily by contractors.

The economics of using reclaimed solvents for equipment wash-up -- including costs of hauling to the reprocessor, reclamation, and repurchasing -- are, in many areas, generally equal to or lower than the total cost of purchasing fresh solvent for this purpose and disposing of the waste in a landfill. However, since the costs vary from area to area and even within a given metropolitan complex, specific comparisons will serve little purpose here. Prices are often related to local competitive forces and/or contractor/customer relationships which require evaluation on a case-by-case basis.

Plant survey data indicate that the costs of Level II technology for this waste stream will not exceed the costs of Level I technology, $50/kkg ($50/ton). This cost is partially offset by the fact that reclaimers usually ship the reclaimed solvent back to the paint plants.

Unless the various solvents are separated by fractionation, which is not as yet customary, the use of the mixed reclaimed solvents is generally limited to wash-up. This discussion is therefore limited to the economics of this application.

Wastewater Sludge

Waste tank cleaning water is settled, water is decanted from the surface, and the sludge is drummed and hauled away to a landfill. The sedimentation cost is not significant since polymeric sedimentation aids are not used and special clarifiers are not generally employed. Thus, the cost of Level II is identical to Level I, or an average hauling and disposal cost for sludge disposal of $50/kkg ($50/ton). This estimate is based on plant survey data.

Collected Dust From Air Pollution Abatement Equipment

The best method encountered during the survey visits for handling this waste stream was reuse as a pigment extender in low-grade paint. Assuming that the dust can be used at the same plant site where it is generated, the cost for reworking this material is negligible. Where the only use for dust is at other manufacturing locations, the transportation cost for trucking this material in 208 liter (55 gal.) drums will be $7/kkg ($6/ton) based on data from another study (35).

Waste Product and Spills

Level II technology is the same as Level I, consisting of hauling the material in drums to an off-site landfill. Hauling and disposal costs average $6/kkg ($5/ton).

Level III Technology

Level III technology is defined as the technology necessary to provide adequate health and environmental protection. Level III technology may be more or less sophisticated or may be identical with Level I or Level II technology. At this level, identified technology may include pilot or bench scale processes providing the exact stage of development is identified.

Raw Materials Packaging

Level III technology for this waste stream is based on segregation of bags containing residues of potentially hazardous materials from other packaging wastes. These bags, which constitute less than one percent of the total stream, should be incinerated with the ash disposed of in a secured landfill.

Recent studies have estimated that incineration costs range from $6 to $17/kkg ($5-$15/ton), while secured landfill for the ash costs $55/kkg ($50/ton)(36)(37). Total hauling costs should not exceed $11/kkg ($10/ton). Assuming that the incincerated waste produces 10 percent ash, the cost for hauling and disposal of the hazardous portion of the waste stream would be $30/kkg ($30/ton). The cost for hauling and disposal of the remainder of the raw materials packaging waste stream remains at about $20/kkg ($20/ton). This assumes negligible cost for segregation of the waste.

Waste Solvent

Level III technology consists of solvent reprocessing with incineration of the still bottoms followed by disposal of the collected ash in a secured landfill. Because of the small portion going to a secured landfill the increase in costs over Level II technology will not significantly affect the total cost which is estimated at $50/kkg ($50/ton).

Wastewater Sludge

Level III consists of sedimentation and dewatering of the sludge followed by disposal in a secured landfill. It is estimated that the overall cost will be about $60/kkg ($50/ton). This assumes the use of a chemical sedimentation aid at a cost of $1/kkg ($1/ton) and a cost for disposal on a secured landfill of $60/kkg ($50/ton).

Collected Dust From Air Pollution Abatement Equipment

Two alternatives are proposed as Level III technology. The first is Level II technology which consists of recycling the dust as pigment extender in low grade paint. The cost of this, assuming the dust can be used at the same site where it is collected, is negligible. However, this reuse concept cannot be applied at all paint manufacturing facilities due to stringent quality control requirements.

The second alternative is hauling the drummed dust to a secured landfill. This practice will cost approximately $60/kkg ($50/ton).

Waste Product and Spills

Based on data supplied in recent reports, the practice consisting of incineration followed by disposal of the residual ash in a secured landfill should cost roughly $40/kkg ($40/ton) (35, 36, 37).

Summary

The costs of the various levels of technology for each potentially hazardous waste stream on a $/kkg ($/ton) basis are given in Table 72.

A crude estimate of the total national costs to the paint industry for waste disposal can be obtained by simply multiplying the waste generation rates from Table 1 (1974 estimates) times the costs shown in Table 72. These costs in thousand dollars are shown in Table 73.

The cost of using Level I technology, $10.4 million per year, is 0.2 percent of the value of shipments for 1972 ($3.9 billion). Implementing Level II or Level III technology should not significantly increase these costs which are currently relatively minor.

The costs to a "typical" large paint plant producing 3.8 million liters (1.0 million gallons) per year of products as defined earlier in the report, would be as shown in Table 74 to use Level I technology.

TABLE 72

Estimated Costs for Levels of Treatment Technology

Waste Stream	Level No.	Cost, $/kkg I	($/ton) II	III
Raw Material Packaging		20 (20)	20 (20)	20 (20)
Waste Solvent		50 (50)	50 (50)	50 (50)
Wastewater Sludge		50 (50)	50 (50)	60 (50)
Dust Collected from Air Pollution Abatement Equipment		6 (5)	0-7 (0-6)	0 (Recycle) 60 (Sec. Landfill) (50)
Waste Product and Spills		6 (5)	6 (5)	40 (Incineration) (40)

TABLE 73

Total National Costs to the Paint Industry for Waste Dispoal

Waste Stream	Level No.	Cost, $\$10^3$/kkg I	($\$10^3$/ton) II	III
Raw Material Packaging		6,000	6,000	6,300
Waste Solvent		3,000	3,000	3,000
Wastewater Sludge		1,300	1,300	1,400
Dust Collected From Air Pollution Abatement Equipment		10	0-11	88 (Landfill)
Waste Product and Spills		62	62	453
Total		10,372	10,362- 10,373	11,241

TABLE 74

Level I Treatment and Disposal Costs for a "Typical" Large Plant

Waste Stream	Waste Generation Rate, kkg/yr (tons/yr)	Disposal Cost $/yr.
Raw Materials Packaging	34 (37)	680
Waste Product	10 (11)	60
Wastewater Sludge	85 (94)	4500
Dust From Air Pollution Abatement Equipment	2 (2)	12
Organic Cleaning Solvent	85 (94)	4500
Total		$9752

SECTION V

HAZARDOUS WASTE PRACTICES OF SOLVENT RECLAMATION OPERATIONS

DESCRIPTION OF SOLVENT RECLAMATION OPERATIONS

Introduction

Organic solvents which become contaminated through industrial use but which are not consumed in a manufacturing process are candidates for reclamation and reuse. The contaminated materials are generated in various chemical manufacturing operations and attendant cleaning of equipment and comprise a portion of some spoiled product. They include a wide range of aliphatic, aromatic, and halogenated hydrocarbons, alcohols, ketones, and esters. These generic groups embrace materials such as methanol, isopropanol, methyl ethyl ketone, methyl isobutyl ketone, amyl acetate, butyl acetate, hexane, benzene, methylene chloride, trichloroethylene, and perchloroethylene.

This section describes the sources of waste solvents and their reclamation as an adjunct of paint and coatings manufacture and by independent operators who contract to collect and distill such waste material from various sources. The economics of on-site reclamation at paint plants are compared with the costs of off-site processing, the future trends and growth rates of such facilities and the solvents handled are discussed, and technology changes are forecast.

On-Site Reclamation at Paint Plants

Organic solvents used in cleaning equipment and for other purposes attendant to paint manufacture become contaminated with pigments, other paint raw materials, or water. The simplest means used to recover them for further use is to settle out the solids in a drum and draw off the supernatant solvent. However, in this method they are cleaned only to a limited extent which inhibits the range of additional use. Thus, many companies are employing commercial distillation units for reclaiming these materials.

In these systems solvents are evaporated from the feedstock and recondensed into a clean storage vessel. When the materials processed are relatively pure containing only non- or low-volatile contaminants, an almost pure solvent will result. When a mixture of solvents is included in the stream being reprocessed, a mixture of solvent vapors will usually be generated depending on temperature and other conditions in the evaporation unit. If a relatively pure solvent is required, the various solvents must be segregated in separate tanks and reprocessed separately or one or more fractionation columns must be used to separate the different solvents. Solvent reclamation at paint plants does not normally include fractionation.

Generally, batch distillation is employed to recover a mixture of solvents which is suitable for tank washing and other cleaning operations. A paint plant usually recovers only its own waste solvents, but some small paint companies who have installed solvent recovery equipment are providing a contract service to other small companies. This permits installation and utilization of an economic size recovery unit. The size factor is discussed below.

Six paint manufacturing plants surveyed during this study have solvent recovery operations as part of their overall process. Surveyed plants represent approximately eight percent of all paint production; extrapolation of survey data thus suggests that approximately 70 paint plants (4.5 percent of all paint plants) reprocess at least some of their waste solvents on-site. The solvents of an additional 16 plants surveyed are reclaimed by private contractors. Based on a percentage of paint production, this indicates that on a national basis approximately 200 paint plants (13 percent of total) send spent solvents to contractors for reprocessing and that 13.6 million liters (3.6 million gal.) per year are currently reclaimed in this manner.

The major source of dirty solvents in paint manufacture is the cleaning of mixing and storage tanks. Hence the solvent normally has a considerable suspended and dissolved solids content which may range up to 10 percent. The equipment used for reprocessing such solvents must be designed so that these solids do not become deposited on the heated surface where they will inhibit heat transfer to the solvent. Scraped surface or agitated thin-film evaporation are normally used. One plant reported the use of a high boiling miscible liquid additive to increase the percentage of solvent recovery while maintaining the still bottoms sufficiently liquid for removal.

Approximately 26 million liters (7 million gal.) of paint industry waste solvents are sealed in 208-liter (55-gal.) drums each year and disposed of in landfills or dumps, thus consuming at least 140,000 drums per year.

Solvent Reclamation by Private Contractor

Contract solvent reprocessing operations vary considerably in size, materials handled, and technology used. Batch stills, coil stills, scraped surface stills, or agitated thin-film evaporators are commonly employed to purify waste solvents.

Two major classes of materials are reprocessed. One is halogenated hydrocarbons such as methylene chloride, tricholoroethylene, perchloroethylene, and 1,1,1 trichloroethane. These spent solvents derive primarily from degreasing and metal cleaning.

The other category includes a wide range of solvents such as aliphatic hydrocarbons, aromatic and naphthenic hydrocarbons, alcohols, ketones, and esters. These waste solvents are generated by the chemical process industry, solvent manufacture and distribution, metal cleaning and coatings, industrial paint use, and printing operations, in addition to paint manufacture.

Numerous special solvents such as freons, phenols, cyanides, and oils are also recovered in small quantities. However, the processing of these materials is not common among conventional solvent reclaiming operations and in some cases they are handled by only one plant. It should be emphasized that by far the majority of contractors who were the subject of this study specifically exclude materials containing cyanides and oil. Plants that accept these materials were among the few which would not allow the survey teams to observe their operations since they consider the processes used proprietary information.

Most of the larger contractors handle both halogenated hydrocarbons and miscellaneous solvents of the types listed above while some of the smaller operations process only the more valuable halogenated hydrocarbons. Two of the surveyed contract plants were of the latter type.

Some of the larger contractors also engage in other resource recovery and waste disposal processes including acid neutralization, thermal oxidation, chemical oxidation and reduction, and operating a secured landfill.

Economic Evaluation

The principal factor affecting the economics of a solvent recovery operation is the size of the system used. Modern equipment varies in capacity from 2.8-6100 liters (1/2-1600 gal.) per hour and the economics improve considerably with size. For example, with efficient operation a 3000-liter (800-gal.) per hour evaporator can recover solvents at one-third the cost per liter or gallon of a 380-liter (100-gal.) per hour unit. The reasons for this are that the relative capital cost per unit of capacity is less as is overhead and maintenance. As shown in Table 75, operating labor costs are similar for all sizes of evaporators so they are considerably less per unit for a larger system.

The economics of a large unit are seriously reduced if it cannot be efficiently utilized due to lack of raw material, which no doubt explains why the larger units are commonly found only in chemical manufacturing plants. A large paint plant producing 1100 liters (300 gal.) per day of spent solvent could not efficiently utilize a distillation unit of greater than 190 liters (50 gal.) per hour.

When a paint plant has an on-site solvent recovery system, it tends to use a greater quantity of solvents for cleaning in the knowledge that they will be recovered. Such a plant will often operate a 380-liter (100-gal.) per hour system over two shifts for better utilization. Another plant of similar size may use a solvent-reclaiming contractor with a 3000-3800-liter (800-1000-gal.) per hour unit and find that transportation costs are offset by the greater efficiency of the larger unit.

In general, paint plants utilize small capacity systems, in the range of 75-380 liters (20-100 gal.) per hour due to the scale of their operation while private contractors will employ larger capacity units up to 1500 liters (400 gal.) per hour, especially when located in a highly industrialized area. Contractors are usually prepared to transport their raw material from considerable distances since increased quantities of feedstock improve the overall operating efficiency of their plant.

Department of Transportation regulations (CFR 8173.28) require "red label" liquids -- those with a flash point below 38°C (100°F) -- to be shipped in new drums or reconditioned ones displaying the reconditioner identification number and the pressure test date. This regulation applies whether the shipment is made by common carrier or in a private vehicle and affects large quantities of spent and reclaimed solvents.

It appears that in many areas these DOT regulations are not enforced and that old drums are being used to ship solvents to and from reclaimers. Strict enforcement of these regulations could add up to 13¢/liter (50¢/gal.) to the total cost of hauling solvent to and from reclaimers in drums.

The actual value of recovered solvent varies considerably with the type of solvent, the size and type of reclaiming process used, the degree of purity of the product, and the general economic climate of the time and place in which it is being sold. Generally, the value of reclaimed solvent is closely tied to the value of the virgin material and will sell for from 50 percent to 90 percent of the value of virgin solvent. Actual prices range from 5¢/liter (20¢/gal.) for simple distillation of cheap solvent up to perhape $3/liter ($10/gal.) for careful refining of a valuable solvent in special equipment. The majority of reclaimed solvents sell within the 10-30¢/liter (40¢-$1/gal.) range.

Table 75 compares costs of a range of sizes of distillation units and is based on information supplied by an equipment manufacturer. Figures given are 1974 costs and apply to facilities being installed in a paint plant or other manufacturing facility. They are minimum costs assuming a constant supply of feedstock on an eight-hour day operation and makes no allowance for additional handling or waste disposal costs.

TABLE 75

OPERATING COSTS FOR A SOLVENT RECLAIMING SYSTEM IN A PAINT MANUFACTURING PLANT

BASIS:
Operation - 230 eight-hour days per year
Operating Costs (steam, electricity) - 1.2 cents per gallon recovered
Labor - 1/3 to 1/2 operator
Overhead - 100% of operating cost & labor
Maintenance - 5% of installed cost
Depreciation - 20% of installed cost

Solvent Recovery Rate	380 liter/hr (100 gph)	1500 liter/hr (400 gph)	6100 liter/hr (1600 gph)
Installed Cost	$54,000	$71,000	$120,000
Solvent Recovered per year	760,000 liters (200,000 gal.)	3,000,000 liters (800,000 gal.)	12,000,000 liters (3,200,000 gal.)
Operating Cost	$2,400	$9,600	$38,400
Labor	$5,000	$5,000	$5,000
Overhead	$7,400	$14,600	$43,400
Maintenance	$2,700	$3,550	$6,000
Depreciation	$10,800	$14,200	$24,000
Annual Operating Cost	$28,300	$46,950	$116,800
Total Recovery Cost	3.8¢/liter (14.2¢/gal.)	1.6¢/liter (5.9¢/gal.)	1.0¢/liter (3.6¢/gal.)

The total recovery costs shown would at least double if the same reclaiming systems were installed on a contractor's site due to the costs of land, buildings, waste disposal, overhead, labor, and auxiliary equipment. However, several private contractors have reduced their costs substantially by purchasing used equipment. In many cases, costs of transporting feedstock will far exceed actual recovery costs.

There are two basic modes of contract operation:

1. The contractor recovers the solvent, returns the material to its source, and is paid either by the quantity of dirty solvent originally taken or by the quantity of clean solvent returned.

2. The contractor buys the spent solvent (or in some cases is paid to haul it away), recovers the solvent, and sells it on the open market.

One of these systems is usually the primary mode with the alternative method accounting for a small portion of a contractor's business. The one favored depends on the system he finds most profitable. Most operations are owned by small individual companies, and only a few companies own more than one plant. Most solvent reclaimers have no substantial financial backing and are therefore limited in production facilities and expansion potential.

Future Trends and Developments

With the rapid increase in the cost of virgin solvents in recent years, the economics of solvent recovery have improved and the growth rate of this industry is increasing. No reversal of this trend is likely to occur in the near future in face of continuing price rises, particularly in petroleum derivatives. In addition, there is a considerably larger market to be tapped since the paint industry alone now disposes of about 26 million liters (7 million gal.) per year of spent solvents which are not reclaimed.

The technology for solvent recovery is relatively simple and well proven so no new developments are likely for reclaiming wash solvents, the bulk of materials handled. It appears, however, that greater use will be made of fractionation towers in the future so that a purer product of greater value can be obtained for more sensitive uses.

Also, reprocessing will move into new fields to recover more complex solvents and other basic materials included with present industrial wastes. Much of the technology for these processes is presently available or under development and only requires an attractive market to stimulate its use.

CHARACTERIZATION OF SOLVENT RECLAMATION OPERATIONS

Introduction

The purpose of this section is to describe the overall structure of the solvent reclaiming "industry" as it applies to private contractors engaged in the reprocessing of organic solvents. Estimates as to the number and geographical distribution of solvent reclaiming contractor operations are given. The age and size ranges of these facilities plus a broad overview of the distribution of the various types of solvents processed are provided. Future trends in the "industry's" growth rate, site distribution, and product handling are also assessed.

Number and Distribution of Facilities

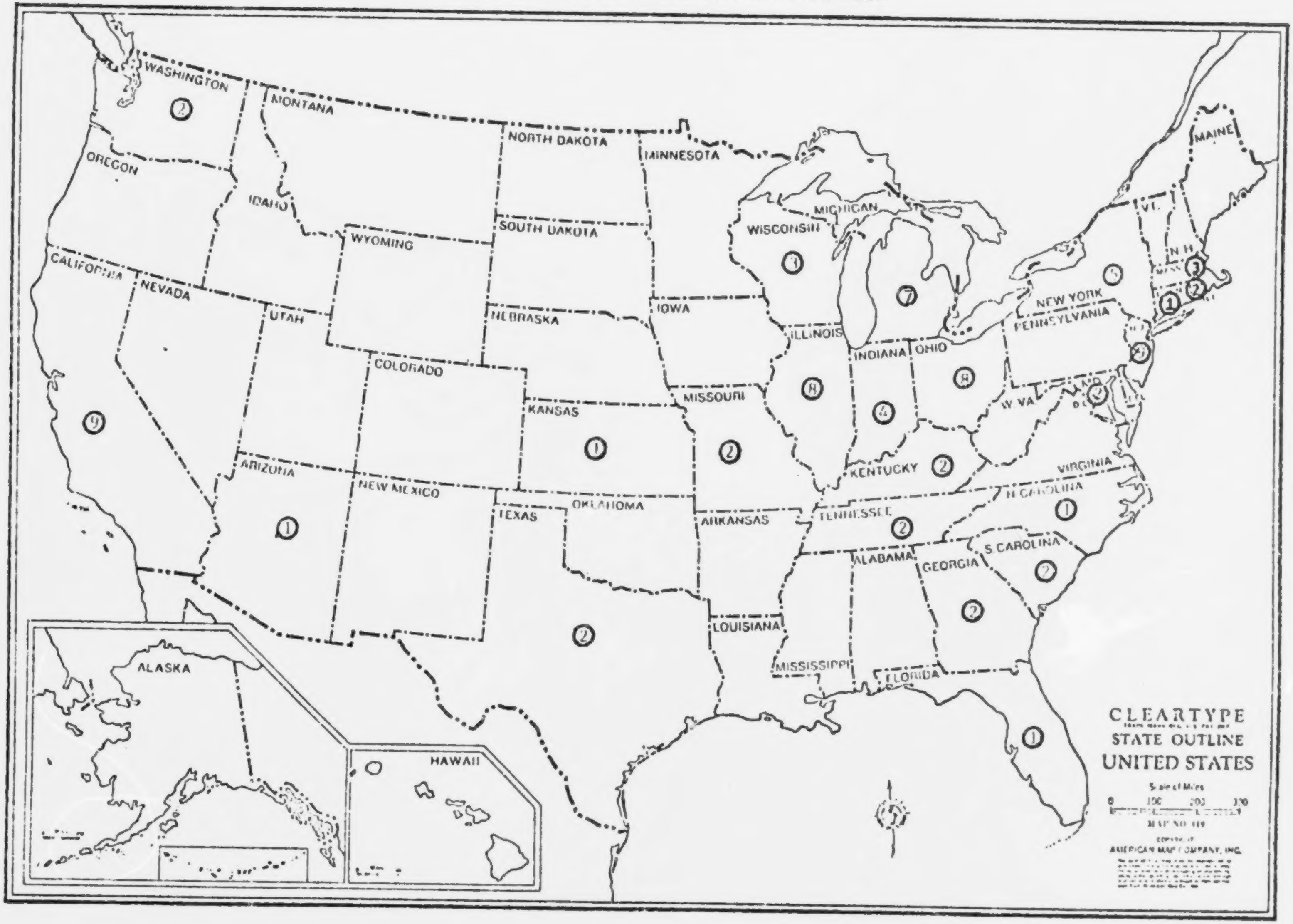
It is roughly estimated that there are 80 to 100 contract solvent recovery operations distributed throughout the United States. Seventy-nine are identified in Appendix G by EPA region and pertinent information is provided where available. Since there does not appear to be a trade association to which solvent reclaimers belong as a group, and they are not broken out as an "industry" by the Census Bureau, this list was compiled from information supplied by paint companies, equipment manufacturers, telephone directories, EPA data, and from solvent reclaimers themselves. There are probably five to 20 additional plants throughout the country which were not identified because they do not advertise, have not bought their equipment from one of the major suppliers, or are not openly competing with other reclaimers in their area.

From the diagram showing the state distribution of the known facilities (Figure 19), it can be seen that they are spread throughout the country's most populated areas which also have large numbers of paint manufacturers. The greatest number of solvent reclaimers are in EPA Region V which encompasses Ohio, Indiana, Illinois, Wisconsin, Michigan, and Minnesota, although none were located in Minnesota.

Any detailed evaluation of their distribution on a state basis is really irrelevant because these operations normally take feedstock from many states. For example, reclaiming operations in New Jersey are accepting waste solvents from the whole Northeastern area from Maine to Virginia. The fact that no recovery contractors have been identified in Pennsylvania does not necessarily mean that solvent reclamation is not practiced in that state. Neither does it imply that all used solvents generated there are discarded. What it may indicate is that they are being shipped to New Jersey and New York in the East and Ohio or other Midwestern states for reclamation. The reason for such out-of-state shipping is not clear, but it does not appear to be related to local regulation of such operations since New Jersey law is very restrictive and the state has many solvent reclaimers.

FIGURE 19

U.S. Distribution of Contract Solvent Reclaimers


WASHINGTON ②
MONTANA
NORTH DAKOTA
MINNESOTA
OREGON
IDAHO
WYOMING
SOUTH DAKOTA
WISCONSIN ③
MICHIGAN ⑦
MAINE
VT.
N.H.
MASS. ③
②
①
R.I.
CALIFORNIA ⑨
NEVADA
UTAH
NEBRASKA
IOWA
ILLINOIS ⑧
INDIANA ④
OHIO ⑧
NEW YORK ⑤
PENNSYLVANIA
N.J.
W. VA.
MD.
D.C.
DEL.
COLORADO
KANSAS ①
MISSOURI ②
KENTUCKY ②
VIRGINIA
ARIZONA ①
NEW MEXICO
OKLAHOMA
ARKANSAS
TENNESSEE ②
N. CAROLINA ①
TEXAS ②
S. CAROLINA ②
ALABAMA
GEORGIA ②
LOUISIANA
MISSISSIPPI
FLORIDA ①
ALASKA
HAWAII
CLEARTYPE
STATE OUTLINE
UNITED STATES
Scale of Miles
0 100 200 300
MAP NO. 119
COPYRIGHT
AMERICAN MAP COMPANY, INC.

The survey data do not indicate any correlation between geographical location, technology used, or waste characteristics. While more West Coast operations are constructed from used equipment instead of new equipment, there is nothing to indicate any difference from facilities in other areas.

Size Distribution

Two parameters were evaluated to determine the size of solvent recovery operations -- i.e., number of employees and quantity of feedstock. The number of employees is estimated to vary between two and 150 although it appears that the vast majority employ less than 20 persons. Only four surveyed plants employ more than 25 people, while 14 plants employ less than 15 people.

These numbers are influenced by many factors. For instance, when a plant collects all of its own feedstock over a wide area a larger staff is necessary for collection and these people do little else. On the other hand, those plants which are essentially captive to a few local suppliers employ fewer collection personnel although they may process as great a volume of spent solvents or more than those with a bigger payroll. In the larger companies engaged in several types of resource recovery operations it is difficult to ascertain the number of employees involved in solvent recovery only. Thus, numbers of employees per se have virtually no relationship to size of solvent reclamation activities. There is also no identifiable correlation between geographical location and number of employees.

There was a paucity of data on feedstock quantities received and those available were of variable reliability. Some plants regarded this information as proprietary and others only kept records of quantities actually recovered and had to estimate feed quantities assuming an average yield of recovered solvent. In the plants visited, quantities handled varied from 98,000 liters (26,000 gal.) per year to 9,100,000 liters (2,400,000 gal.) per year, and averaged 2,600,000 liters (680,000 gal.) per year for those who provided data.

Forty percent of the plants surveyed are fully utilizing their equipment on a 40-hour per week basis while many are operating at approximately half their potential capacity. This is due to the fact that equipment was initially overdesigned to allow for expansion. Capacity can be further increased by operating more hours per day on a shift system.

Under-utilization is most frequently the result of the unavailability of sufficient quantities of used solvents. No connection was found between the size of reclaiming operations in terms of volume of feedstock process and geographic location.

Sufficient data were obtained on 30 plants to classify them generally into size of operation and type of materials handled. Out of the 30 surveyed plants, 11 were small operations -- i.e., less than 760,000 liters (200,000 gal.) per year -- dealing entirely in chlorinated and fluorinated solvents. Another four were small operations accepting a wide range of solvents; five plants were of medium size at 760,000-3,800,000 liters (200,000 to 1 million gal.) per year handling all types of solvents; and there were 10 large plants which handle more than 3.8 million liters (1 million gal.) of dirty solvents of all types each year. Extrapolation to a national basis suggests the size classification of solvent reclaiming contractors shown in Table 76. Due to inherent inaccuracies in the extrapolation, actual numbers may vary within a range of about ±15 percent from those given.

Age Distribution

Of the surveyed plants which were less than ten years old, all but one had less than 400,000 liters (100,000 gal.) per year of processing capacity. Most of the older plants (20-40 years) had 4-19 million liters (1-5 million gals.) per year of capacity. This reflects a recent trend toward building reclaiming facilities to handle specialized solvents such as trichloroethylene. While most of the newer solvent reclaiming operations are small, one plant only five years old was found to be one of the largest in terms of number of people employed. The oldest plant visited has been in operation for 35 years while three others were less than one year old. In general, the older plants are located in the older industrial areas in the Northeast and Midwestern areas. Thirty-five percent of the plants surveyed had been in operation for 25 or more years; thirty percent were from six to 25 years old; and the remaining 35 percent has been operating five or less years. Many of the older plants have recently installed new equipment so the technology used is similar in all plants and not dependent on age.

Production Distribution

The distrubution of quantities of solvents reclaimed follows very closely the distribution of solvent usage throughout the country. For example, the distrubution of paint production by EPA region shows that Region V encompasses the largest number and is followed by Regions II, IX, and IV. Similarly, the number of solvent reclaimers is greatest in Region V followed by Regions II, IX, and IV.

All areas have a range of plant sizes with small plants reclaiming from 98,000 liters (26,000 gal.) per year and larger plants up to 9.5 million liters (2.5 million gal.) per year. Detailed information on quantities of spent solvents handled was obtained from 12 plants and is discussed in a later section.

TABLE 76

ESTIMATED SIZE CLASSIFICATION OF SOLVENT RECLAIMING CONTRACTORS

Capacity Range, million liters/year	Contractors Handling Only Halogenated Hydrocarbons		Contractors Handling Most Types of Solvents	
	Number	Percent of Total	Number	Percent of Total
Small <0.76	30-38	100	11-13	21
Medium 0.76-3.80	0	0	13-16	26
Large >3.80	0	0	16-33	53
Total	30-38	100	40-62	100

Future Trends

While many of the small reclaimers dealing only in halogenated hydrocarbons will continue in operation, the trend is towards larger operations which also engage in other resource recovery and waste disposal practices. Although the reclaimers surveyed predicted a 10 to 35 percent annual rate of growth in amount of solvent available to their plants, this growth rate is not expected to continue for many years and is likely to reduce to the order of five percent per annum in a more stable economic environment. In addition, more solvent-using manufacturers are installing equipment for on-site recovery of solvents, a practice which will tend to minimize the need for the services of a contractor.

Enactment of environmental legislation prohibiting the deposition of solvents in landfills may increase the quantity sent to reclaimers, but in some cases the solvents would be disposed of by incineration.

SOLVENT RECLAIMING WASTE CHARACTERIZATION

Introduction

Although detailed data were obtained from 12 contract solvent reclaimers, in light of the variety in the types of operation and almost certain inaccuracies in estimating feedstocks and waste quantities, it is very difficult to extrapolate this information to the total number of plants in the whole country. Thus, actual quantities discussed below could be within ±30 percent of the values stated.

Feedstock Sources and Quantities

Solvent recovery contractors are generally reluctant to identify the sources of their feedstock. This is a highly competitive business which requires a constant search for new sources of feedstock and prices are negotiated with each individual customer. Because of these factors, it is understandable that they will not disclose names and will only discuss broad industrial classifications so that sideline industries are not pinpointed. The quantities from each source are likewise unavailable.

The following list identifies some of the major industries which provide feedstock for solvent recovery contractors:

- Chemical processing
- Solvent manufacture and distribution
- Metal cleaning and coating
- Resin manufacture
- Dry cleaning
- Paint manufacture
- Factory application of paint
- Electronics industry
- Vapor degreasing
- Industrial printing

The only groups of solvents which could be separated from the whole and approximately quantified were the chlorinated and fluorinated solvents used in vapor degreasing, metal cleaning, and in the electronics industry.

Linear extrapolation of the information from the 12 surveyed plants with data to an estimated 92 plants results in the following estimates: a total feedstock each year of approximately 230 million liters (60 million gal.) of dirty solvents of which 60 million liters (16 million gal.) are chlorinated and fluorinated solvents, approximately 160 million liters (41 million gal.) are aromatics, aliphatics, alcohols, ketones, esters, etc., and the remaining 10 million liters (3 million gal.) are miscellaneous materials such as freons, oils, etc.

The feedstock is usually transported from its source to the recovery plant by the recovery contractor in his own trucks. More than 50 percent is transported in 208 liter (55 gal.) drums and the remainder is transported in bulk tankers. Normally, a minimum number of tractor units are operated to deliver a large number of tanks, flat tops, and covered vans to the premises. At this point, tractor units and drivers can be put back on the road while tanks, drums, and vans are being unloaded to bulk storage. Two surveyed plants have rail sidings for receiving and shipping bulk and drum material.

Solvent Reprocessing Methods

The basic principles involved in solvent reclaiming are evaporation of the solvent from the feedstock and condensing the vapor back to liquid form. There is a wide variety in the type and size of equipment used. Their characteristics range from those of large continuous process distillation equipment available in major chemical manufacturing operations to small "homemade" stills utilized by small reprocessing contractors.

Two of the plants surveyed employ proprietary methods for the recovery of solvents from difficult sludge and gel type solids. These were small operations and no details of the process were available.

While design details vary, four basic methods are used to evaporate the solvent to be reprocessed:

1. Direct Injection of Steam. Steam is injected directly into the liquid to be evaporated. Solvent vapors pass from the evaporation into a condenser where liquid solvent is collected. This method is only suitable for those solvents which have low boiling points, are not miscible with water, and can be readily separated from water. Because of these limitations, this type of still is not commonly used and is normally confined to small specialized operations.

2. Coil Still. In this equipment, illustrated in Figure 20, the vessel containing the material to be distilled contains a coiled tube through which steam or hot fluid is passed to heat the contents. Electric heating coils are also used. Heat transfer is fast and efficient, providing no fouling occurs on the heat transfer surface. This type of equipment is not suitable for reprocessing solvents which have a high solids content (roughly five percent or more) or contain resinous materials which could polymerize on the coils and require expensive hand cleaning. Evaporated solvent passes to a non-contact water-cooled condenser where liquid solvent is collected.

Stills of this type are widely used for reprocessing solvents such as chlorinated hydrocarbons used in dry cleaning operations. They range from 28 to 950 liters (8 to 250 gal.) per hour capacity.

3. Scraped Surface Still. In this device, the distillation tank is surrounded by a heating jacket and the interior of the cylindrical heated surface is continuously wiped by scrapers attached to a central rotating shaft. This is best suited for use with solvents containing sludge or solids and insures a clean heat transfer surface by keeping resinous materials in the still bottoms liquid so that they can be removed from the still. A scraped surface still is shown in Figure 21.

4. Agitated Thin-Film or Wiped-Film Evaporator. This type of still utilizes a tall vertical cylinder surrounded by a heating jacket. Rotating blades within the cylinder agitate the solvent and force it to flow in a thin film down the interior heated surface of the cylinder. These blades do not scrape the surface but the clearance is sufficiently small to prevent the liquid film from adhering to the surface. Thin film evaporators vary in capacity from 400 to 6100 liters (100-1600 gal.) per hour.

After evaporation, the vapors pass into a condenser for recovery of the liquid. Condensers are normally of the non-contact surface water-tube type so that there is no contamination of the cooling water. If there is an adequate supply of makeup water, the cooling water is discarded after passing through the condenser but in most operations the water is recycled through a cooling tower or spray pond. This type of equipment is shown in Figure 22.

Whether solids and non-volatile materials collected in the bottom of a still or evaporator are removed at the end of a batch or continuously, depends on which type of equipment is used, and the mode of operation. "Still bottoms" are kept sufficiently fluid so that they can be removed by pumping which simplifies handling and minimizes spills. Still bottoms are incinerated or sealed in drums for land disposal.

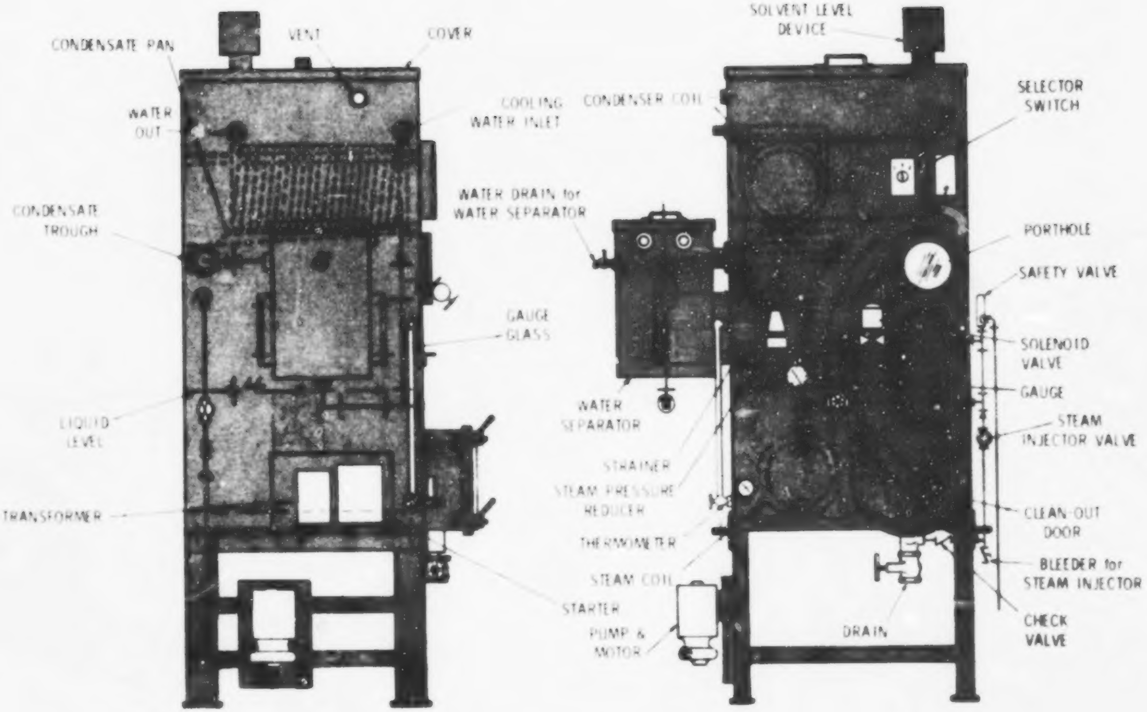

CONDENSATE PAN
VENT
COVER
WATER OUT
COOLING WATER INLET
CONDENSATE TROUGH
GAUGE GLASS
LIQUID LEVEL
TRANSFORMER
STARTER
SOLVENT LEVEL DEVICE
CONDENSER COIL
SELECTOR SWITCH
WATER DRAIN for WATER SEPARATOR
PORTHOLE
SAFETY VALVE
SOLENOID VALVE
GAUGE
WATER SEPARATOR
STEAM INJECTOR VALVE
STRAINER
STEAM PRESSURE REDUCER
CLEAN-OUT DOOR
THERMOMETER
BLEEDER for STEAM INJECTOR
STEAM COIL
PUMP & MOTOR
DRAIN
CHECK VALVE

FIGURE 20

STEAM COIL STILL

Courtesy: Detrex Chemical Industries, Inc.

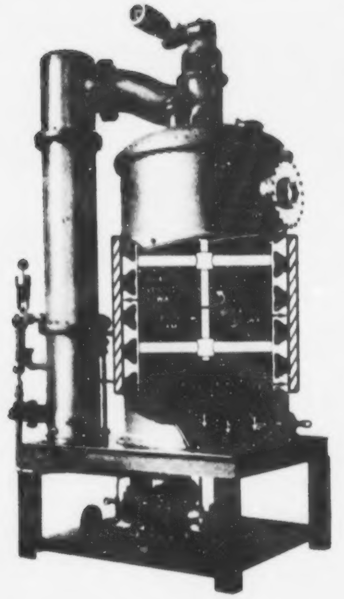


FIGURE 21

SCRAPED SURFACE DISTILLATION PLANT

Courtesy: Brighton Corp.

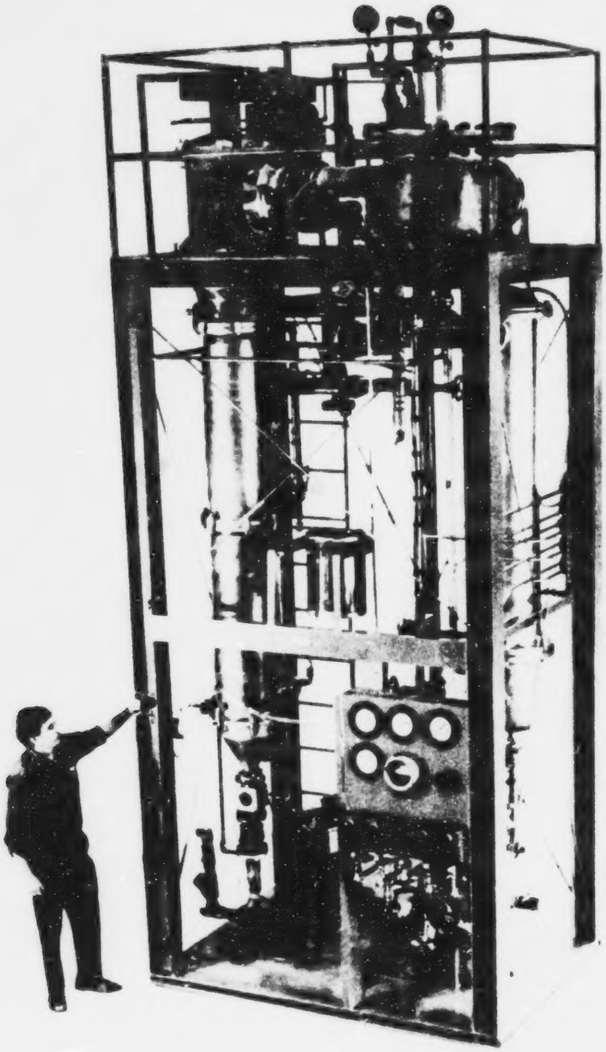


FIGURE 22

THIN - FILM SOLVENT RECOVERY PLANT

Courtesy: Luwa Corp.

All solvent recovery systems require little direct operating labor, but considerable labor is required in collection, testing, and feeding of used solvents to the recovery equipment.

When separation of solvents or fractionation is required, a tray-type or packed fractionation column is used between the evaporator and the condenser to control the temperature of vapors passing to the condenser.

Waste Sources

Figure 23 shows the principal equipment used and an approximate mass balance diagram of a typical solvent recovery plant. Figures given relate to the processing of 100 kg (220 lb) of feedstock. The process diagram is essentially the same for all types of stills and evaporators. Variations occur primarily only when a fractionating tower is added to the basic distillation equipment.

Steam is normally used at 8.5 atm (125 psig) pressure. In some specialty evaporators, the jacket is designed for higher pressures so that higher distillation temperatures can be obtained. An alternative to using high pressure steam is to use heat transfer oil such as Dowtherm*. Another common approach to the distillation of solvents with high evaporation temperatures is the use of vacuum pumps or steam jets to reduce the pressure within the evaporation unit so that the solvents vaporize at lower temperatures.

There is only one basic waste stream from solvent recovery operations -- i.e., the still bottoms or sludge. Occasionally, this stream is incinerated on-site and the remaining ash residue becomes the waste stream.

Sixteen samples of still bottoms were collected during survey visits and later tested to indicate the potentially hazardous nature of these wastes. All samples were analyzed for volatile fraction as an indicator of the portion of solvent remaining in the waste. Similarly, the flash point of all samples was determined to see if any of the wastes could constitute a fire hazard. In addition, samples known to contain metal compounds were tested for lead, chromium, and zinc concentrations.

The samples of still bottoms obtained from chlorinated solvent recovery alone were tested for trichloroethylene (as this was known to be in the samples). When significant quantities of trichloroethylene were found, the presence of other chlorinated solvents was not determined. Similarly, chlorinated hydrocarbons were not sought in other samples where there was no indication that these materials would be present in other than trace quantities.

---

*Use of a trade name does not constitute endorsement of a product.

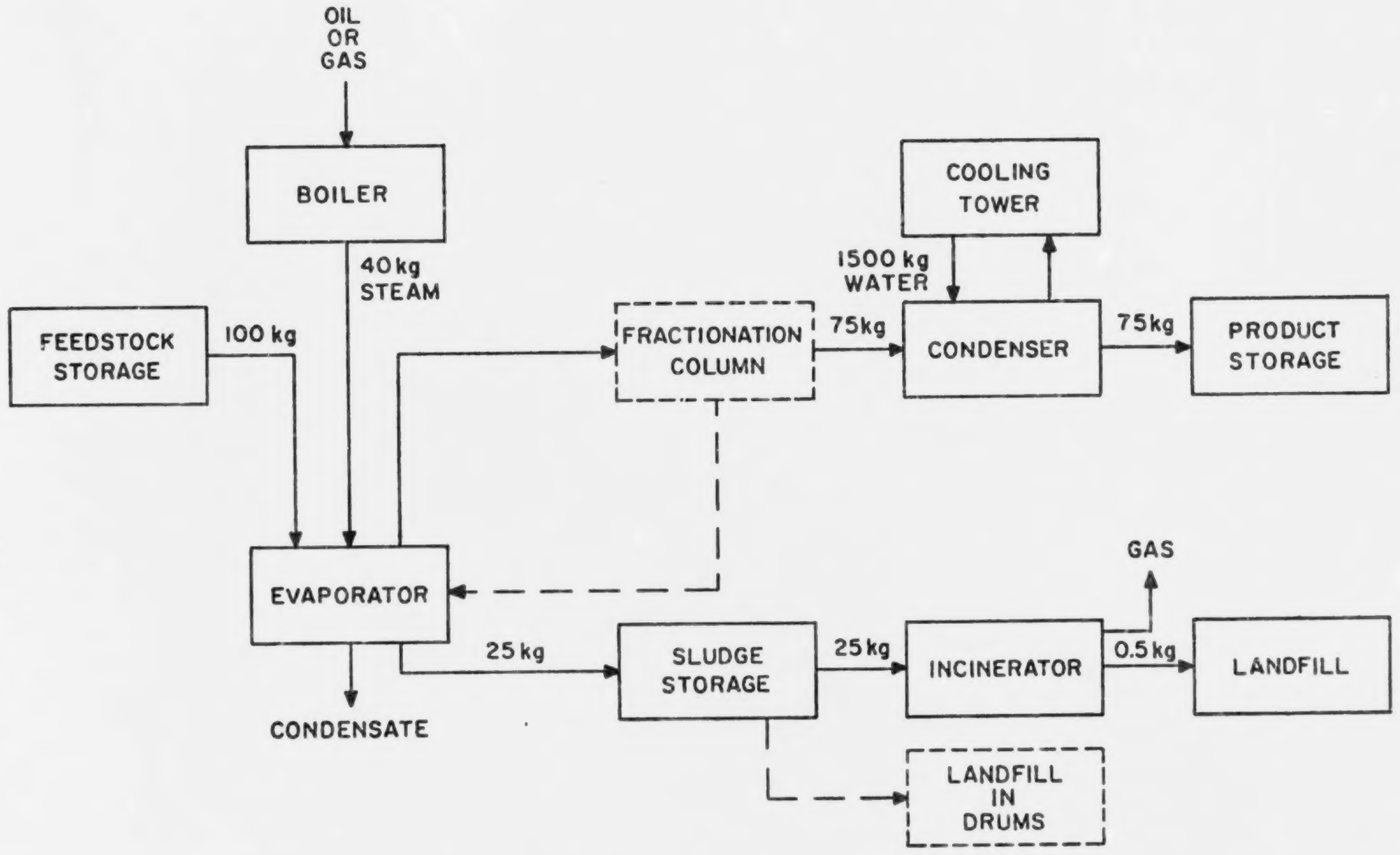

OIL
OR
GAS
BOILER
40 kg
STEAM
FEEDSTOCK
STORAGE
100 kg
EVAPORATOR
CONDENSATE
FRACTIONATION
COLUMN
75kg
1500 kg
WATER
COOLING
TOWER
CONDENSER
75kg
PRODUCT
STORAGE
25 kg
SLUDGE
STORAGE
25 kg
INCINERATOR
GAS
0.5 kg
LANDFILL
LANDFILL
IN
DRUMS

FIGURE 23

TYPICAL SOLVENT RECOVERY SYSTEM

It was stressed by plant operators during the site visits that the concentration, and even presence of various hazardous materials fluctuated. This is due to differences in the characteristics and origins of the various batches of feedstock received during any given time period.

The results of the laboratory analyses are given in Table 77. These analyses are grab samples of specific operations at a particular time only and cannot be considered representative of the solvent reclaiming industry as a whole or even the specific solvent reclaiming operations from which the samples were collected.

The findings may be summarized as follows:

1. The majority of samples have a high volatile fraction indicating a large proportion of solvent and other volatile organics.

2. All flash points are above 27°C (100°F) indicating that these sludges do not constitute a serious fire hazard.

3. Waste streams from the recovery of chlorinated hydrocarbons contain considerable quantities of chlorinated solvents and therefore must be considered a potentially hazardous waste stream.

This stream, either as a sludge or an ash, must be considered potentially hazardous principally because of the variability and uncertainty in the nature and quantity of its constituents. Some feedstocks come from painting operations which contain varying quantities of metallic or other compounds which are potentially toxic, flammable, or both. Another large portion of the feedstock derives from cleaning and other industrial operations which also contribute to the toxic and/or flammable nature of the materials concentrated in the sludge during the distillation process.

Twenty-six percent of these feedstocks, on a national basis, contains quantities of potentially toxic halogenated hydrocarbons. These solvents have a Gleason toxicity rating of 3 or greater (1). The remaining 74 percent of the feedstock contains solvents which also have a toxicity of 3 or greater (1). These materials normally contain a small percentage of toxic heavy metals but actual quantities vary considerably and few wastes can be considered free of this potential hazard. Eighty-five percent of these materials is incinerated, so that toxic elements may be concentrated in the ash requiring final disposal. The criteria for determining the hazardous nature of wastes from solvent reclaiming operations are the same criteria applied to paint industry wastes earlier in this report -- i.e., streams containing materials with a Gleason toxicity rating of 3 or greater (1) and/or containing solvents with a flash point of 27°C (80°F) or lower are considered hazardous.

Solvent reclaiming wastes are not usually stored on the recovery site but are shipped to other disposal facilities. However, one plant surveyed was accumulating the incinerator ash on-site until an acceptable disposal method was found.

TABLE 77

ANALYTICAL CHARACTERISTICS OF STILL BOTTOMS SAMPLES COLLECTED FROM SOLVENT RECLAIMING OPERATIONS

Sample Designation	Percent Volatile Carried off at 103-105°C	Percent Trichloroethylene	Lead, mg/l	Chromium, mg/l	Zinc, mg/l	Flash Point, °C	Flash Point, °F
A_1	77		1700	280	190	48	118
A_2	79		500	60	130	44	111
B_1	89		400	60	130	51	124
B_2	89	6				75	167
D_1	99		100	10	10	40	104
D_2	41					46	115
J_1	14	3				no flash	
J_2	14					58	136
J_3	61					53	127
J_4	28					90	194
X_1	97	45				84	183
X_2	97	50				86	187
Y_1	59		1200	360	100	68	154
Y_2	58		1200	310	990	82	180
Y_2'	83		100	10	10	74	165
Z	61		3700	730	430	79	174

The drums in which the feedstock is collected are not considered a waste stream since they are recycled for collection of further material, used to package saleable products, or to contain waste for disposal in a landfill. When drums are to be used for product, they may be cleaned with solvent and the cleanings added to the feedstock for recovery. As noted earlier, strict compliance with Department of Transportation regulations requires the use of new or reconditioned drums which have been subjected to a pressure test for all three purposes if the flash point of the content is below 38°C (100°F).

Solvent reclaimers occasionally acquire some feedstock which cannot be processed through their recovery operation. This often means shipping unsuitable material back to its source. Quantities of this type of material are minimized by clearly specifying the quality and nature of the material that they will accept.

Only minor quantities of unsuitable feedstock are considered a waste stream from solvent reclaiming operations since it does not generally constitute a waste which is normal to these operations. It is more correctly designated as a waste stream from the generating industry and as such should be considered in conjunction with the other wastes of that industry.

No data were available to this study on the methods employed for disposal of sludges or dust generated in air pollution control equipment used on incinerators burning still bottoms. Incinerators used at two survey facilities were operating within local air pollution standards without the use of any air pollution abatement equipment.

Waste Quantities from Solvent Reclamation

Waste quantities were obtained from 10 of the surveyed operations. These facilities represent between 21 and 32 percent of the feedstock processed on a national basis. They are representative of the range of still types employed and solvents processed, however, there is no evidence that these factors affect the rate of recovery. Rates tend to vary with each individual batch of feedstock and the operation of individual evaporators.

On the average, 75 percent of the feedstock is recoverable solvent which is sold as a product based on information obtained during the survey visits. The remaining 25 percent constitutes the waste stream from the recovery operation. This 25 percent includes the still bottoms or sludges and small quantities of feedstock which for various reasons are not suitable for evaporation. On this basis, it is estimated that 56 million liters or 54,000 kkg (15 million gal. or 60,000 tons) of waste sludge are generated annually in this country from the processing of 230 million liters (60 million gal.) of feedstock. The accuracy of this calculation is probably ±30 percent.

Some of the larger solvent reclaimers individually dispose of up to 1.9 million liters (500,000 gal.) of these sludges each year.

Two of the plants surveyed make some use of the waste sludge. One small plant handling only chlorinated solvents was selling approximately 8000 liters (2000 gal.) per year as an asphalt extender. Another was incorporating a small quantity of waste sludge into a building product. Both these uses account for less than 0.1 percent of the total waste on a national basis and thus cannot be considered typical disposal methods.

The largest portion of the still bottoms waste stream is the base solvent left in the sludge to keep it in a fluid form. The solids include oils, greases, and metal fines from metal cleaning operations, pigments, extenders, and resins from paint residues, organic contaminants from chemical processes, etc.

Total estimated present and projected national waste quantities from contract solvent reclaiming operations are summarized in Table 78.

The projections for 1977 and 1983 are based on a 10 percent annual average growth rate between 1974 and 1977 and an average of five percent per year for the next six years. Actual growth rates will depend on the general economic situation and environmental controls which may be imposed but cannot be predicted at this time.

These figures are quantities from the contract solvent recovery industry and do not include waste solvents directly disposed of from paint manufacturing facilities or other industrial operations nor waste residues from solvent reclaiming processes operated on-site as a captive process at such installations.

No quantitative data were available to this study on the content of ash from the incineration of still bottoms of contract solvent reclamation operations. However, Table 79 analyzes the concentration of constituents found in the ash from on-site incineration of solvent recovery still bottoms at a surveyed paint plant. This table is used for illustration only and should not be construed as typical of any reclaiming operations.

TREATMENT AND DISPOSAL TECHNOLOGY

Introduction

This section describes the present technology employed by organic solvent reclaimers to dispose of their still bottoms wastes. The

TABLE 78

ESTIMATED TOTAL WASTES FROM SOLVENT RECLAIMING OPERATIONS

	WASTE VOLUME		WASTE WEIGHT(1)	
Year	Million liters/yr	Million gallons/yr	Thousand kkg/yr	Thousand tons/yr
1974	56	15	54	60
1977	76	20	73	80
1983	101	27	97	107

---

(1)Based on an estimated density of 0.96 kg/1 (8.0 lbs/gal.)

TABLE 79

ANALYSIS OF ASH FROM INCINERATED STILL BOTTOMS

Constituent	Concentration, Percent
TiO_2	Major
SiO_2	15.00
SrO	2.00
Al_2O_3	.50
Fe_2O_3	.20
MgO	.20
BaO	.10
MoO_3	.004
PbO	.03
Sb_2O_5	.02
CaO	.005
NiO	.005
SnO_2	.005
ZnO	.003
CoO	.003
MnO	.003
CuO	.001
Cr_2O_3	.001

Not Detected in Sample: Cd, As, Te, B, W, Ge, Bi, Be, V, Ag primary disposal method used (Level I technology) is incineration, either on-site or by an off-site contractor. Only 14 percent of the waste goes directly to a landfill, and other methods account for only a fraction of the total waste disposal.

Levels II and III treatment and disposal technologies are also identified, the amounts of waste subjected to landfill and incineration are extrapolated to national quantities, and future trends in growth and total wastes are projected.

Description of Present Technology

Information on waste disposal technology was obtained from a total of 18 reclaiming facilities which represent about 20-25 percent of such operations. Fourteen of these facilities incorporate incineration as at least a part of their waste disposal system; ten use incineration exclusively with only the ash going to a landfill, usually at some other location.

Six plants reported using their own on-site incinerators while others make use of a contractor's incinerator. Only the larger companies employ their own, and most of these would not allow survey personnel to inspect their installations. However, from observation of the installations that were inspected, it was determined that a large variety of different types of incinerators are apparently suitable for still bottoms burning. Since most of the still bottoms still contain some organic solvents they are readily combustible and do not require drying or the use of supplementary fuels. The simplest form used consists only of a combustion chamber into which the sludge is pumped through a spray nozzle and into which an adequate air supply is blown.

One of the incinerators inspected that was able to operate within applicable standards without any air pollution abatement equipment achieved combustion temperatures of 1400-1700°C (2500-3000°F) and maintained stack gas temperatures above 870°C (1600°F). Other incinerators incorporated some air pollution control measures such as wet scrubbers. One such plant had experienced the emission of metal oxides which were not collected by the scrubber. Operators of these incinerators reported insufficient ash buildup to require continuous ash removal, and removal is normally performed manually when the incinerators are shut down.

Approximately 14 percent of the wastes from solvent reclaiming goes directly to land disposal, and as nearly as could be determined, the disposal sites are landfills which are covered on a daily basis. The wastes are normally sealed in 208-liter (55-gal.) drums before leaving the plant. One plant reported that it was not allowed to deposit drums of concentrated solvent waste in one landfill, but the licensed landfill would accept this waste if it were distributed over and mixed with a large quantity of garbage.

Two plants were using still bottoms as asphalt extender and concrete block fillers, but this type of use represents less than 0.1 percent of the total waste disposal on a national basis. The chlorinated solvent waste still bottoms from one southern plant were being transported to an off-site contractor for deep well injection disposal.

No general pattern of transportation of wastes to disposal was apparent. Some reclaimers use their own trucks to take wastes to disposal while others use general waste disposal contractors to remove waste material.

Analysis of Number of Locations and Percentage of Total Wastes Disposed

No contractor engaged solely in solvent recovery was equipped for final disposal on his plant site. A few of the larger companies which operate a solvent reclamation process as part of a much larger materials recovery and waste disposal operation include the still bottoms with other waste for incineration and final disposal of their ash in their controlled landfills. However, the use of municipal or private landfills is a much more prevalent practice.

Of the estimated 54,000 kkg (60,000 tons) of still bottom wastes generated annually, it is estimated that approximately 7600 kkg (8400 tons) go directly to a landfill of some kind. The remaining 46,400 kkg (51,600 tons) are incinerated. As previously mentioned, the quantity of ash resulting from these incinerators is very small and is estimated to be a maximum of two percent by weight of the total incinerated. On a national basis, it is therefore estimated that a total of 940 kkg (1030 tons) of ash is produced each year from the incineration of solvent recovery wastes.

Insufficient data are available to estimate with any accuracy the proportion of wastes which are incinerated on-site versus those incinerated by private contractors. Among those plants with quantitative waste data only 12 percent of the waste is being incinerated on-site, but many of the large companies which were unable to supply quantitative data are using on-site incineration. Nationally, 50 percent is probably incinerated on-site. Once again, the accuracy of these nationally extrapolated figures are estimated to have an accuracy of within ±30 percent.

From this discussion, it can be seen that the total quantity of solvent recovery waste requiring final disposal is therefore estimated to be 8500 kkg (9400 tons) per year at the present time -- i.e., 8000 kkg (8900 tons) from the solvent reclaiming industry and 500 kkg (500 tons) as waste from contract incinerators.

Levels of Treatment and Disposal Technology for the Potentially Hazardous Waste Stream

As shown in Table 80, Levels I and II technology consist of on-site

TABLE 80

SOLVENT RECLAIMING STILL BOTTOMS WASTE DISPOSAL

Factor	LEVEL I (Prevalant Technology)	LEVEL II (Best Technology Currently Used)	LEVEL III (Technology Adequate Health and Environmental Protection)
Physical and Chemical Properties	Organic liquid containing toxic constituents. Can contain flammable constituents	Same as Level I	Same as Level I
Description of Residual Waste	Ash with high percentage of potentially toxic constituents	Same as Level I	Same as Level I
Factors Affecting Hazard Potential	Flammability and toxicity	Same as Level I	Same as Level I
Treatment/Disposal Technology	Incineration followed by ash disposal in a sanitary landfill	Same as Level I	Incineration with air pollution controls followed by ash disposal in a secured landfill
Estimated Number of Plants Now Using Technology	50-70	Same as Level I	None
Adequacy of Technology	Inadequate due to possible leaching from landfill*	Same as Level I	Adequate
Problems and Comments	Small quantities of sludge generated sometimes make on-site incineration economically unattractive. Possible air pollution from incineration. Possible leachate problems.	Same as Level I	Same as Level I
Non-Land Environmental Impact	Possible air pollution from incineration. Possible leachate problems.	Same as Level I	Availability of secured landfills
Compatability with Existing Facilities	Good	Same as Level I	Same as Level I
Monitoring and Surveillance Techniques	None	Same as Level I	Incinerator stack gas monitoring; leachate and runoff monitoring in landfill
Installation Time	1-3 years to incinerator	Same as Level I	Same as Level I
Energy Requirements	Minimal. Little supplemental fuel needed for incinerator. Fuel for trucking ash to landfill and covering.	Same as Level I	Same as Level I

+

---

*Possibly toxic to landfill microbes.

and off-site incineration of still bottoms with ash disposal in a sanitary landfill. Still bottoms incineration with proper air pollution control to meet applicable standards followed by ash disposal in a secured landfill is an environmentally acceptable disposal practice which constitutes Level III technology for this industry.

Future Trends

The overall trend in this industry is towards greater resource recovery and more efficient disposal of wastes. It is also foreseen that better use will be made of solvent recovery equipment so that a greater portion of solvent is recovered, thus reducing the quantity of waste. Also, recovery of other materials (e.g., metals, organic chemicals) will be undertaken if the economic climate changes and these processes become financially attractive.

As recovery plants grow in size, greater use will be made of incineration for waste disposal but until regulation dictates otherwise there will continue to be a number of small plants sending wastes direct to landfill. It is probable that a number of future incinerators will incorporate heat recovery systems so that the energy value of the material burned is not wasted.

The use of still bottoms in byproducts such as asphalt extenders will be further researched and will probably develop into a significant waste disposal method.

While the industry is expected to expand at a high rate, the rate of growth in quantities of final waste for disposal will be considerably less due to increased use of improved methods. In estimating the future quantities in Table 81 the quantity going to landfill has been kept constant; the increase is attributed to greater quantities of ash from incineration.

COST ANALYSIS

Reclaimers generally pay between 1 to 4¢ per liter (5-15¢ per gal.) for disposal of still bottoms wastes through another contractor. One plant reported, however, that it spends 7¢ per liter (27¢ per gal.) for waste disposal off his site by a private contractor using incineration.

Plants operating their own incinerators were unable to give accurate incineration cost figures but the estimates they supplied also fell within the 1-4¢ per liter (5-15¢ per gal.) range. One plant using land disposal at a cost of 1¢ per liter (5¢ per gal.) had discontinued contract incineration service when charged 4¢ per liter (14¢ per gal.) for waste disposal.

TABLE 81

SUMMARY OF ESTIMATED QUANTITIES
OF WASTES FROM SOLVENT RECOVERY OPERATIONS

kkg/yr (tons/yr)

	Quantity of Feed Stock		Quantity of Waste From Solvent Recovery		Quantity of Waste For Land Disposal	
1974	205,000	(225,000)	54,500	(60,000)	8,500	(9,400)
1977	287,000	(316,000)	73,000	(80,000)	9,400	(10,300)
1983	385,000	(425,000)	97,000	(107,000)	10,900	(12,000)

With the volume of waste approximately one-third that of the saleable product, the cost of waste disposal is between 0.5 to 1.3¢ per liter (2-5¢ per gal.). This plays a significant part in the overall economics of the process since wastes represent approximately 25 percent of the volume of the feedstock.

SECTION VI

HAZARDOUS WASTE PRACTICES IN FACTORY-APPLIED COATINGS OPERATIONS

DESCRIPTION OF FACTORY-APPLIED COATINGS OPERATIONS

Introduction

The term "factory-applied coatings" refers to coatings which are applied as an integral part of product manufacture. Since, in many cases, the coating process is not separated from the other manufacturing steps, it is difficult to characterize it as a distinct operation.

In general, the coatings used are easily separated from "trade sales" products in that they are tailored for a specific end use and method of application and cure which may be highly sophisticated. Very rapid cure is usually desirable to minimize the amount of space needed to store products while they are drying to the point where they can be packed and shipped.

Because of the large number of factory applications of these coatings and the wide variation in size, little information about the industry as a whole can be offered within the scope of this section of the project. Only broad generalizations are possible with the information presently available.

Economic Structure

There is no Standard Industrial Classification for the factory application of coatings. Instead these operations are spread among almost all the groupings that cover manufacturing, and, as a result, there are no valid statistics as to their number and size. Estimates may be found that range from 15,000 to over 50,000, depending upon the definitions used and the assumptions made. The contractor estimate is about 45,000 which includes approximately 25,000 relatively small operations and some 20,000 plants which use significant quantities of coatings. Since they are generally encompassed within a manufacturing operation, their distribution parallels that of industry.

The market for the coatings used provides about the only effective source of information on the relative size of various divisions of the

Preceding page blank

industry. This information is contained in the 1972 Census of Manufactures report "Shipments of Industrial Finishes" which is shown in Table 82. This list includes industrial maintenance paints and marine paints, which, while often specially formulated for factory application, are not "factory-applied paints" in the context of this investigation, since the waste problems associated with them are much more closely akin to the waste generated by other types of coatings designed for non-industrial use. The table also separates "industrial product finishes, except lacquers," from "industrial lacquers, including acrylics." When corrections for these differences are made, the total shipment of factory-applied coatings, in 1972, was 1207 million liters (319 million gal.), valued at $996.8 million. The largest consumption was in automobile finishes, 151 million liters (40 million gal.), container and closure finishes, 131 million liters (34.7 million gal.), and wood product lacquers, 135 million liters (35.8 million gal.).

Many smaller factory-applied operations buy some or all of their paint through trade sales or similar channels which is not reported in Table 82. Also, many of the larger plants buy substantial amounts of solvents for thinning paints through sources other than the paint industry -- often directly from a solvent manufacturer. These two sources would increase the consumption by a significant, but unknown, amount.

Future Trends and Developments

This limited investigation of factory applications of coatings was not designed to establish precise trends and future developments in this field. This discussion, therefore, is based largely on contractor knowledge, supplemented by information acquired during the plant visits and conferences with other experts.

In general, future trends are influenced most heavily by sources outside the industry and to a much lesser degree by internal pressures. Among the factors with the greatest effect on the future of the industry are air and water pollution regulations, occupational safety and health regulations, shortages and/or increasing costs of certain raw materials, particularly those derived from petroleum, and increasing costs of fuels and other restrictions on energy, especially on natural gas and fuel oils used for baking and incineration of coatings and solvents. The national economy in terms of product consumption will also be a significant factor.

Another set of exterior forces which will produce substantial changes in the industry are new methods of application and new coatings adapted to them, such as powder coatings, ultra-violet cured coatings, electrostatic deposition, electrophoretic deposition, and electron-beam curing. Each of these methods is now employed to a limited extent in a few specific uses, but the development of improved coatings and techniques will expand their usage to a marked degree in the near future. It is difficult to forecast the extent of the expansion, but

TABLE 82

1972 CENSUS OF MANUFACTURES
SHIPMENTS OF INDUSTRIAL FINISHES

SIC Code	Product	Total Product Quant., M̄gals*	Shipments Value, $M̄*
28516	Total Industrial Product Finishes, except Lacquers	279.3	929.0
2851611	Interior Industrial Maintenance Paints	14.0	57.3
2851613	Exterior Industrial Maintenance Paints	20.3	67.6
2851618	Marine Paints	9.0	42.5
2851631	Automobile Finishes	40.0	127.3
2851633	Truck and Bus Finishes	4.9	16.3
2851635	Railroad Finishes	3.7	11.1
2851637	Other Transportation Equipment, including Aircraft, Rockets and Missiles	3.9	12.9
2851638	Appliances, Heating Equipment and Air Conditioner Finishes	17.5	60.3
2851641	Wood Furniture and Fixture Finishes	18.0	43.3
2851642	Wood and Composition Board Flat Stock Finishes	10.2	30.2
2851644	Sheet, Strip & Coil Coatings, including Sidings, except Containers	14.2	60.0
2851645	Container and Closure Finishes	34.7	102.6
2851646	Other Metal Decorating	8.9	30.0
2851647	Machinery and Equipment Finishes, except Insulating Varnish	13.9	46.7
2851648	Metal Furniture and Fixture Finishes	10.8	37.3
2851651	Paper and Paperboard, excluding Pigment Binder	4.4	11.6
2851652	Industry Varnishes, Electrical Types	9.5	29.2
2851653	Powdered Coatings	0.4M lbs.	6.3
2851698	Other Industrial Product Finishes, except Semi-manufactured Products Such as Pigment Dispersions & Ink Vehicles	20.9	69.5
2851600	Industrial Product Finishes, except Lacquers, not Specified by Kind	20.1	67.0
28517	Total Industrial Lacquers, including Acrylics	83.0	235.2
2851711	Automotive Lacquers	16.3	57.1
2851721	Wood Product Lacquers	35.8	78.3
2851731	Fabricated Metal Lacquers	8.4	32.8
2851741	Paper and Paperboard Lacquers	3.5	8.1
2851798	Industrial Lacquers for Other End Uses	12.4	40.1
2851700	Industrial Lacquers, including Acrylics, not Specified by Kind	6.6	18.8
	TOTAL SIC 28516 & 28517	362.1	1164.2
	TOTAL FACTORY APPLIED COATINGS	319.0	996.8

---

* M̄ = million.

estimates which seem to be as good as any available were shown earlier in Table 6 (6). Certainly the increasing costs of coatings and their raw materials will continue to put pressure on the development of methods to reduce waste in their use.

FACTORY-APPLIED COATINGS OPERATIONS CHARACTERIZATION

Introduction

The descriptions in this section of the number, size, and distribution of factory-applied coatings operations and accompanying comments are based on contractor experience, the literature, and plant visits as well as discussions with trade associations, magazine editors, and others. Installations of 13 companies representing some 200 plants were visited. They represent less than one percent of the estimated number of plants applying industrial coatings.

Number, Size, and Distribution of Manufacturing Plants

There is no compilation of the number of industrial plants which apply surface coatings. It is the contractor's estimate that there are at least 45,000 establishments in the U.S., although this may be low. Many of these, probably at least half, are relatively small, since in many manufacturing operations only a small amount of coating is applied, or, alternatively, coatings are applied to only a small fraction of the materials manufactured.

It is difficult to develop a good yardstick by which to measure the size of these operations since nearly all are embedded in a larger manufacturing operation and there are few units of measurement which are applicable across the range of all types of operations. For purposes of discussion, the number of gallons of coating (including thinner) consumed during a given period is used here. An operation that uses less than a drum of material (208 liter (55 gal.)) a month may be regarded as "very small." At the other extreme, an operation that uses at least a tank wagon of coating a month (13,250 liters (3500 gal.)) may be regarded as "very large." There is no information, however, as to the distribution of plants by size.

Since the factory application of coatings is usually an inseparable part of the total manufacturing operation, the finishing room is located within, or closely adjacent to, the rest of the processes involved. There is no relation between the size of a manufacturing operation and its consumption of finishing materials.

The small portion of coating plants visited during the study cannot be considered representative. Those visited are probably using more advanced technology than the industry average since some operations were selected for on-site survey on the basis that they are conducting active research and development programs, or had published data on their operation. Some visits were made to corporate headquarters which provided data on the company's entire operation rather than quantitative data from a particular plant. The biggest plants visited were applying approximately 3.8 million liters (1 million gal.) of coatings per year. The smallest operation visited was a job coating shop using 26,500 liters (7000 gal.) per year.

Process Distribution

No concrete information is available on process distribution. There is some relationship between size and type of process used in that certain processes (brush paints, for example) are used in very small plants only while other processes (such as electrocoating) are confined to very large operations due to the size of the capital investment required.

Annual Coatings Usage

Table 82 shows the 1972 Census of Manufactures figures on quantiites of coatings sold, the most recent year for which data are available. As mentioned previously, these figures are probably low by an unknown amount.

Many corporate officers contacted during survey visits were unable to supply quantities of coatings used at each of their plants or in the company as a whole, but in several cases data were obtained on the quantity of paint used per unit of product. The following are order-of-magnitude estimates from a number of sources of the quantities of paints used in coating some common products:

Automobile	19 liters	(5 gal.)
Household Stove	1 liter	(0.27 gal.)
Household Refrigerator	0.6 liter	(0.17 gal.)
Room Air Conditioner	0.4 liter	(0.1 gal.)
Clothes Washer	1.9 liters	(0.5 gal.)
TV Set	0.08 liter	(0.02 gal.)
12-Ounce Cans	4.7 liters/1000 cans	(1.24 gals./1000 cans)
Wall Paneling	0.04 liter/m^2	(1.0 gals./1000 sq. ft.)
Furniture (average case goods)	0.8 liter	(0.2 gal.)

At some surveyed plants where quantities of coatings applied were not readily available, estimates were made from total value of paint purchased and the average price per gallon. The ten companies who supplied quantitative data in this manner collectively use 60 million liters (16 million gal.) per year. These do not include the automobile manufacturers who were unable to supply estimates of quantities used at their plants. Thus, the data gathered represent less than five percent of the total quantity of factory-applied coatings.

The surveyed plants are using a wide range of different types of coatings including solvent-thinned paints, water-thinned paints, lacquers, and powder coatings. Relative quantities are not identified here as the surveyed plants are not representative of the industry as a whole and any comparison or extrapolation of survey data could be misleading.

FACTORY-APPLIED COATINGS OPERATIONS WASTE CHARACTERIZATION

Introduction

The waste generated by factory-applied coatings operations is very largely a function of the application method used. The method, in turn, may be dictated by the size and shape of the article being coated, the curing conditions available or suitable, and the type of coating required. Some methods of application, notably spray application, produce substantial amounts of waste. Others, such as roller coatings, produce little or none. The various methods are described in this section along with their relative waste production and the constraints which suggest or inhibit the use of specific methods.

Application Methods

Spray Coating

The most common method of coating application in the factory is spray coating. In its simplest form, this procedure consists of the use of one or more hand-held guns, which the operator can turn on or off and direct to any part of the work. Coatings and air are delivered to the nozzle of the gun by separate lines, mixed, and sent to an aperture under sufficient pressure to atomize the paint into fine particles. The size of the individual particles of spray and the size and shape of the spray pattern can be regulated by adjustments of pressure and of the nozzle aperture. Conventional spray coating is illustrated in Figures 24 and 25.

There are several variations of the spray application method which incorporate modifications designed to reduce the manual labor required, to reduce the waste from overspray that does not strike the surface to be coated, and/or to increase the uniformity of application. These include the automatic, airless, and electrostatic spray systems.

In the automatic types, the spray gun is fixed to a support and is turned on and off as work pieces are moved in front of it by a

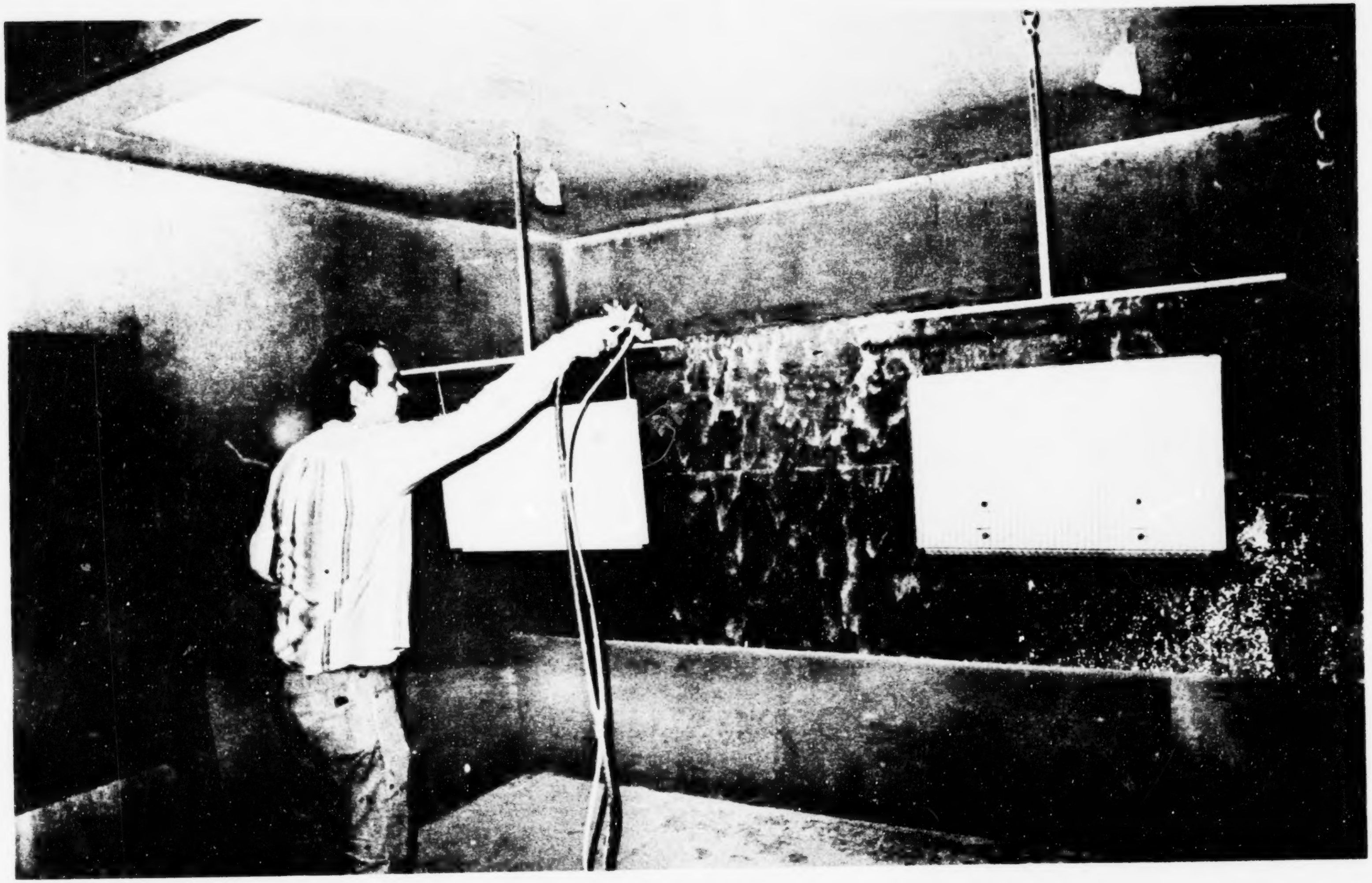


FIGURE 24

CONVENTIONAL SPRAY IN WATER-WASH BOOTH

Courtesy: Industrial Finishing Magazine

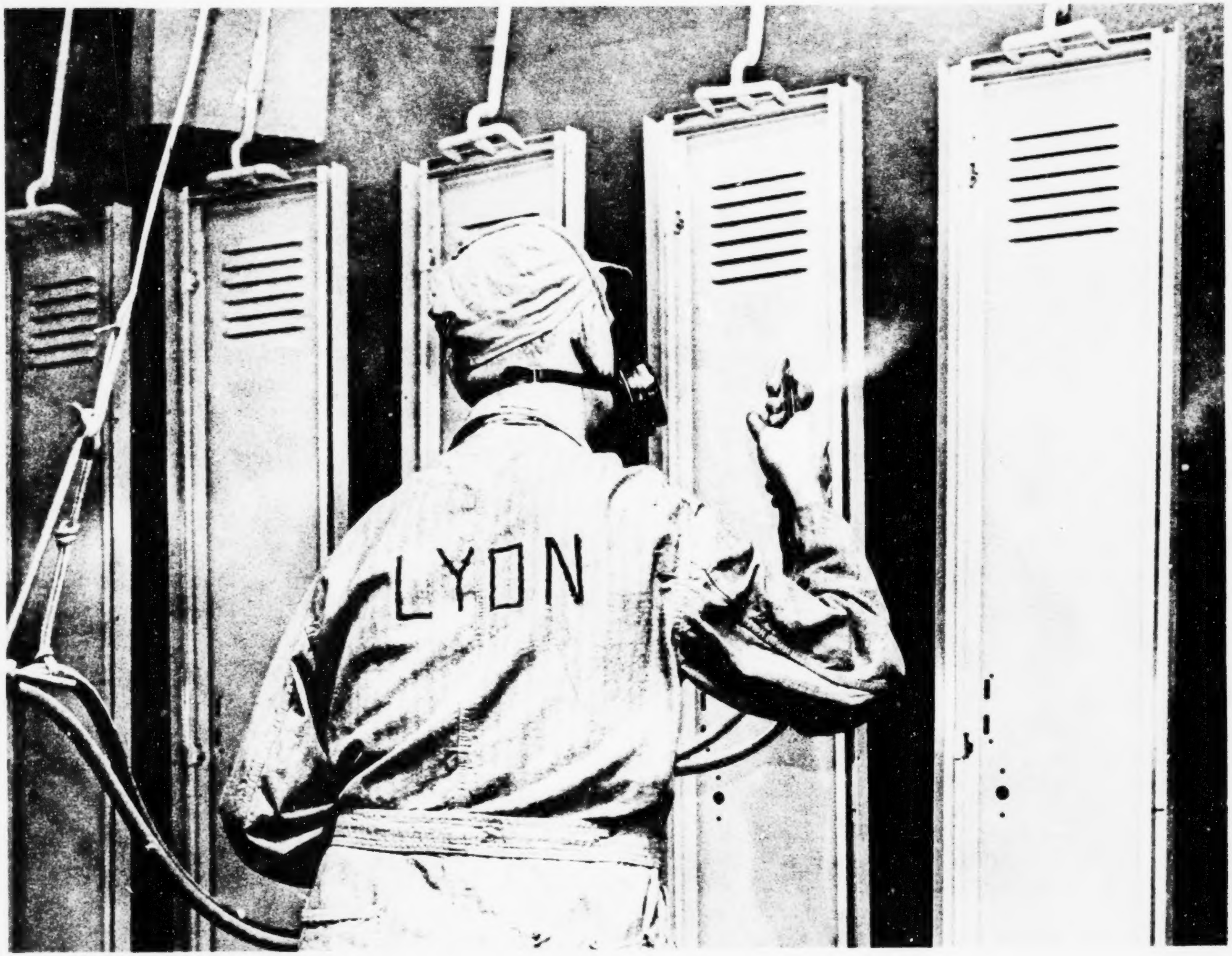


FIGURE 25

FINAL TOUCHUP OF LOCKER DOORS WITH CONVENTIONAL AIR - ATOMIZED SPRAY GUN

Courtesy: Industrial Finishing Magazine

conveyor. Either the gun or the object or both may be adjusted to give a uniform coverage. This method uses less labor, improves uniformity of coverage, and, often, can be adjusted to reduce overspray. Its drawbacks are its restriction to regularly-shaped objects that can be covered evenly in this fashion and the need for long runs of identical items so that mechanical adjustments do not need to be altered frequently.

In the so-called airless spray method, no air is required since the pressure at which the coating is delivered to the nozzle is sufficient to atomize it. This produces a smaller and more accurately defined pattern and thus reduces overspray. However, a much finer nozzle is needed in order to atomize the coating properly without the assistance of air. The use of this type nozzle requires very careful straining of the coating to remove any particles that will not pass through the nozzle and continuous inspection to take corrective action when the nozzle is plugged. Thus, airless spray is rarely used in the automatic mode.

In the electrostatic spray variation, a strong electrostatic charge (about 100,000 volts) is given to the item to be coated and the gun nozzle is given the opposite charge which is transferred to the atomized coating as it leaves the gun. The coating particles are attracted to the opposite charge on the work piece and are deposited on it. Even particles which initially miss it will be attracted to the reverse side of the article being coated. Overspray is thus greatly reduced. In addition, this method promotes uniform coverage. Where paint is deposited on the surface of the object, the charge in that area is reduced and ultimately is changed over to the charge of the coating. This serves to repel additional paint which is attracted to other areas which have not yet been adequately covered. The principal drawbacks to electrostatic spray are that it can only be used on materials that will take and hold an electrostatic charge, and the hazards associated with the use of high voltages, especially around flammable materials.

There are other methods of electrostatic coating, all of which utilize the same basic principle but which differ in the manner in which the coating is atomized and directed. Two of these are spinning discs and bell equipment.

Roll Coating

In this method of application, the coating is applied to a roller which transfers it to the object by rolling contact. Usually the paint is applied to the coating roller by another roller which dips into a trough of coating. In general, the process is very similar to printing. The rollers used vary in structure and smoothness, depending upon the nature of the surface being coated. In some cases, where the surface is unusually rough or irregular, the coating roll will be operated in the reverse direction to the movement of the sheet. This "reverse roll coating" forces the coating into cracks and crevices and yields a more uniform coat.

Roll coating is largely limited to flat, or nearly flat surfaces, with which the roller can make contact. A major use is for coil coating as shown in Figure 26. The hand-held lamb's wool roller, often used for architectural coatings, is rarely used for factory-applied coatings. There are occasional, specialized tasks where this method might be used, but they are uncommon.

Dip Coating

As the name implies, in this procedure the object to be coated is dipped into the coating, allowed to drain, and then dried. The thickness of the coating is largely determined by its consistency. Problems occur on the lower edge of many articles where excess coating accumulates. Various methods have been tried to prevent this, some more successful than others.

Dip coating is, in general, limited to relatively small articles because the size of tank required for larger items and the amount of coating to fill it are uneconomic, except in special conditions. It is also limited to those articles whose shape permits them to be easily immersed in the coating and will allow them to drain smoothly after removal. A variation of this procedure is used with wires, cables, strapping tape, and similar continuous materials. The material is run through a bath of the coating, passed through a die of suitable size to remove excess coating, put through an oven for curing, and rewound on a spool.

Flow Coating

This general name is given to a range of processes with some characteristics of both spray and dip coating. The coating flows from a nozzle without pressure while the material to be coated passes underneath. Excess coatings are collected and immediately recycled. The thickness of coating may be controlled by the size of the nozzle and the speed at which material is passed under the nozzle. A roll or doctor blade may be used to remove excess amounts from flat sheets.

Powder Coating

In this method, the coating, in the form of a dry powder, is applied to an object and is fused to its surface and smoothed out by heat in excess of the powder's melting point. The powder may be applied from a fluidized bed where it is kept suspended in the air by a gentle

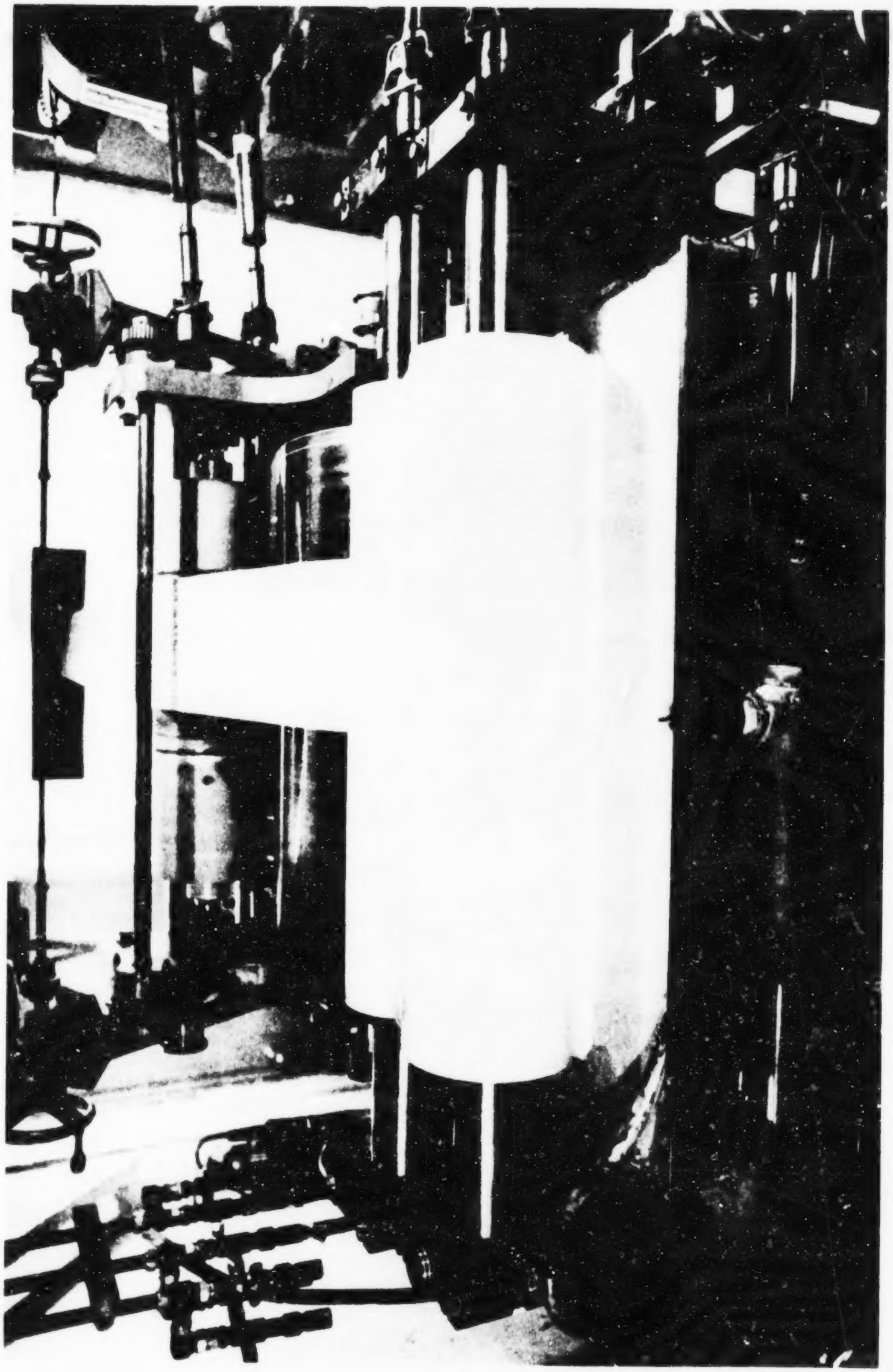


FIGURE 26

COIL COATING APPLYING WOOD GRAIN

Courtesy: Industrial Finishing Magazine

air current blown through the bottom of the container. The article to be coated is heated to the proper temperature and inserted into the bed. The powder is softened by the hot object and adheres to it. The coated article is then transferred to an oven where the fusion is completed. Fluidized bed powder coating is illustrated in Figure 27.

Another variation of powder coating is more recent and uses an electrostatic spray method for the application as shown in Figure 28. (The principle of this method is the same as that discussed in electrostatic spray above). The electrostatic charge keeps the powder on the surface until it can be fused.

Powder coating is particularly appropriate when a very thick coating is needed. There is no upper limit to the film thickness that can be obtained in one coat as there is for any coating containing solvent. On the other hand, the method is not very satisfactory for very thin coatings since the uniformity of thickness required is difficult to attain. In addition, it cannot be used on any material, such as paper or wood, that cannot be heated to the temperature required to melt the coating -- usually about 121-149 C (250-300 F).

Electrocoating

Electrocoating is the most recent development in industrial coating application methods and some of its aspects remain proprietary. The fundamental of the process is the ionization of a coating dispersed in a dilute water solution. The resin, which also contains the pigment, is caused to migrate to the surface to be coated under the influence of an electric current. The method is essentially the same as metallic electroplating, except that, depending upon the choice of resin, the coating can be deposited on either the anode or the cathode. It is shown in Figure 29.

The method is excellent for irregular shapes since the electric charge will carry coating into inaccessible areas. It is widely used, for example, for automobile bodies and wheels.

The limitations of the method include the large quantity of materials needed, particularly for large tanks, the very limited number of resins which can be made to ionize satisfactorily, and the fact that only metallic objects capable of conducting current can be coated. In addition, application by this procedure is usually limited to one coat since the paint deposited is non-conductive and precludes application of further coats by the same process.

Miscellaneous Application Methods

A number of other methods are occasionally used in the factory

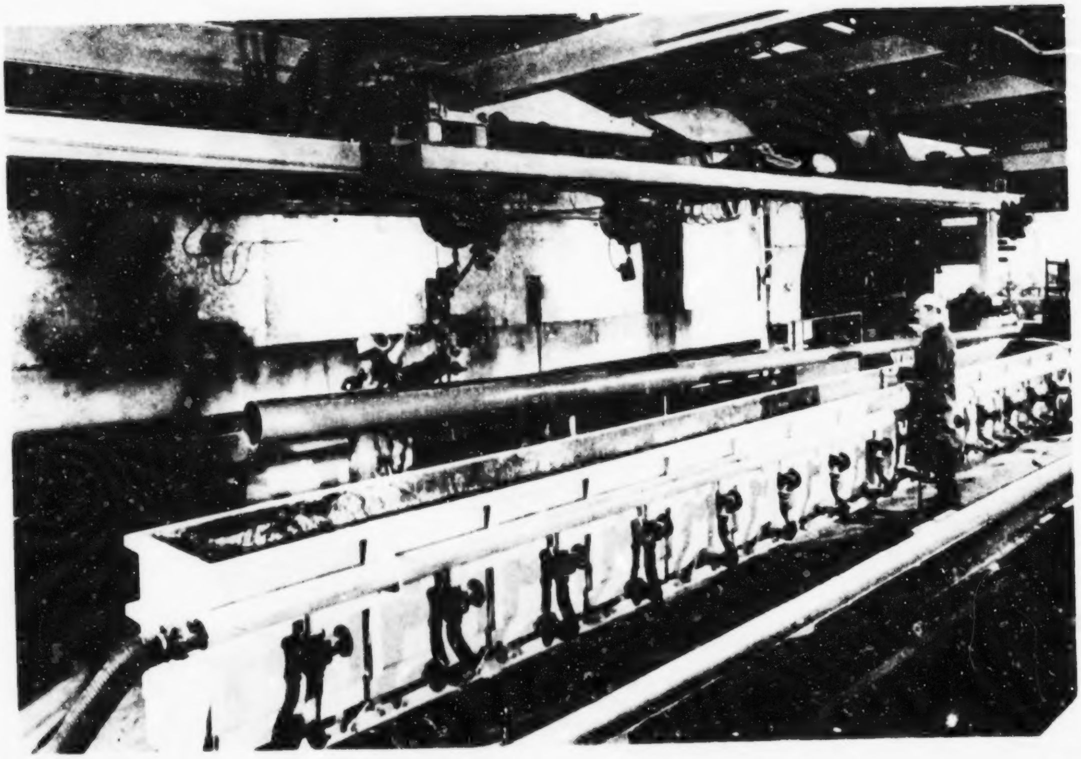


FIGURE 27

FLUIDIZED BED POWDER COATING OF PIPE

Courtesy: Industrial Finishing Magazine

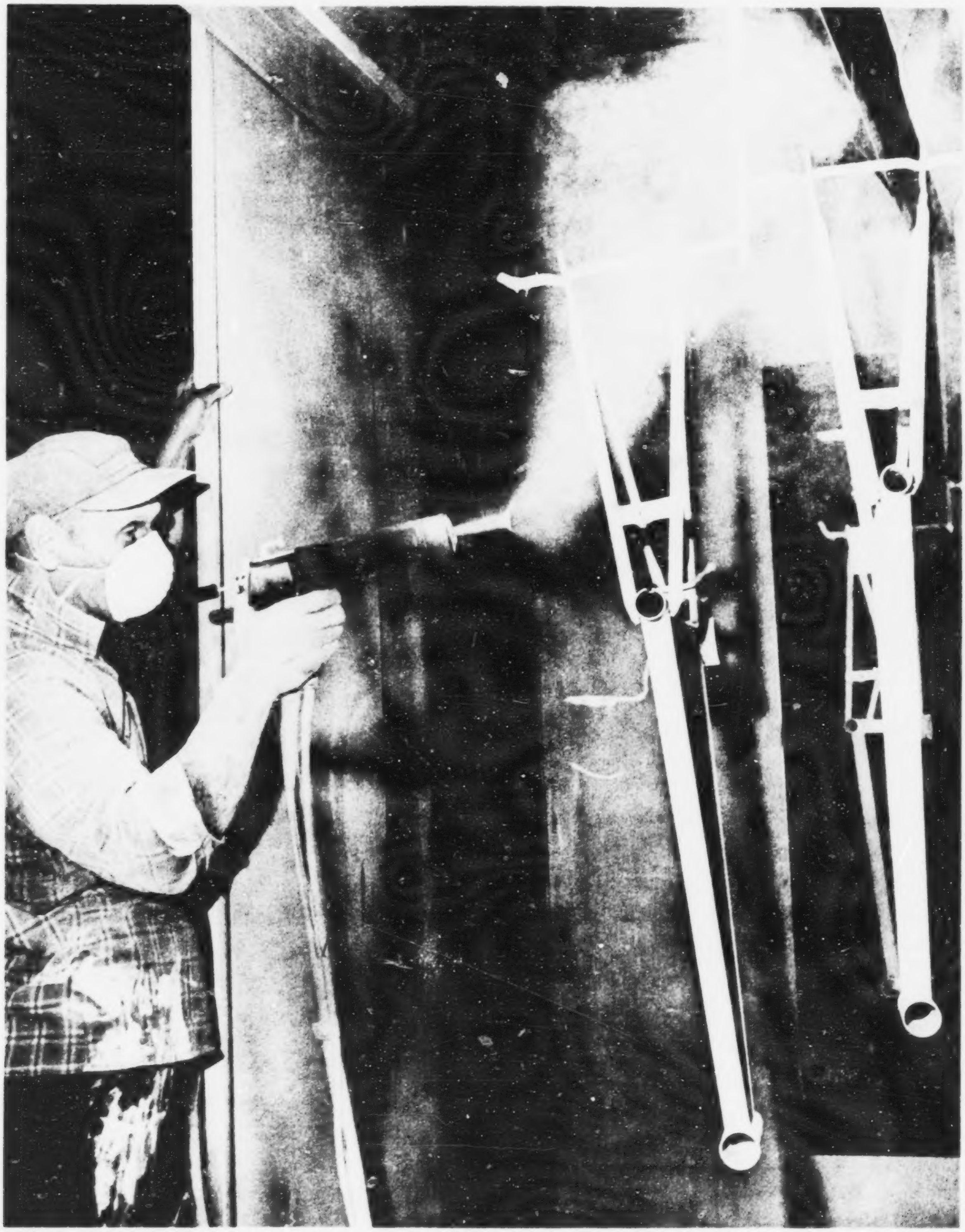


FIGURE 28
ELECTROSTATIC POWDER COATING

Courtesy: Industrial Finishing Magazine

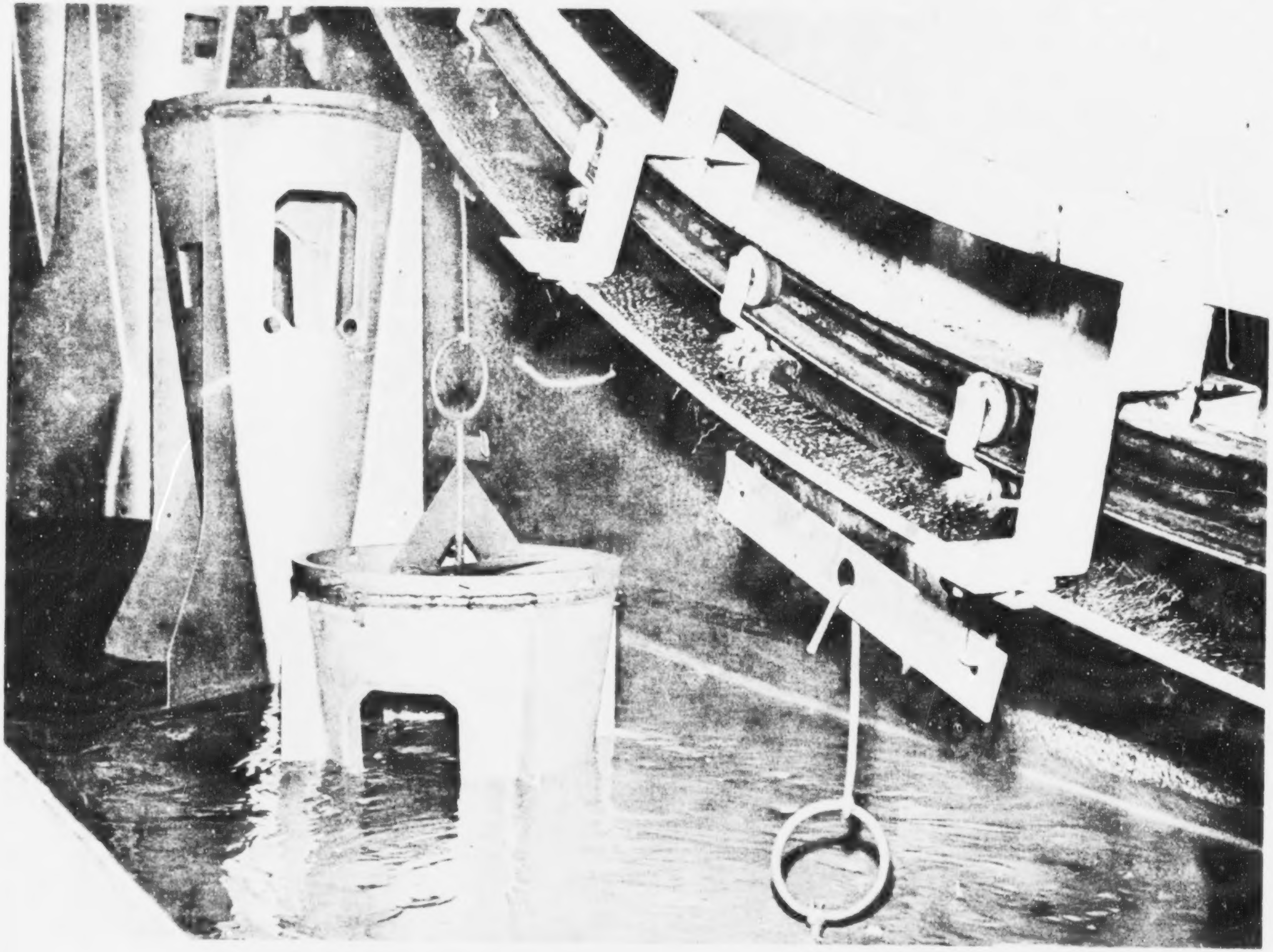


FIGURE 29

ELECTROCOATING BOMB FINS
Courtesy: Industrial Finishing Magazine

application of coatings. Some of these are brush application (frequently used for repair or touch-up), tumbling (used for small objects like belt buckles), and slush coating, in which cans, drums, etc., are coated by pouring the coating into them, rotating the container until a uniform coating is obtained, and pouring the remaining contents into the next one. None of these methods contribute a significant amount of waste and they are used so infrequently that their total contribution of waste is negligible. None of them were employed by the plants visited.

Coating Technology in Specific Industries

Many industries use a variety of coating application methods for their products while in others with more universal technology, one method dominates. The application procedures described above are in general use in the plants visited.

Automobile manufacturing and assembly plants use almost all of the different application methods for different components of cars. Electrocoating processes appear to be a popular method of applying water-thinned prime coats although wet-wall spray booths, flow coating, and conventional dip are also widely used. While research is underway on water-thinned paint suitable for application as top coats on car bodies, the finishing coats used today are principally solvent-based enamels and acrylics applied by spray processes. Electrostatic disc application is employed for some components and powder coatings are used in a small number of plants. A wide range of drying methods is also used in this industry including conventional ovens, electro-curing, and radiant energy drying.

The furniture industry uses organic solvent-based coatings almost exclusively. In the surveyed plants a large portion of the lacquers employed have been reformulated to comply with Rule 66-type regulations for air emissions. Spray methods are used to apply between 90 and 95 percent of the coatings at the two surveyed furniture plants. The other small portion was applied by roll coating methods (i.e., -- imitation wood grain printing) to a flat sheet prior to its assembly into a unit of furniture.

A surveyed can manufacturing plant is using both roll and spray coating methods. The large bulk of the paint is applied to flat metal by roll coating before the can is formed. A final lining coat is applied to the inside of some cans by spray. The latter is done both to coat the soldered joint in the can and to ensure that the final interior coating is not damaged in shaping.

A major appliance plant surveyed in the study was found to be using flow coat application methods for prime coats and electrostatic sprays for surface coats. This manufacturer is using principally water-thinned paints in these processes, a practice which is not general in this industry. A large proportion of solvent-thinned paints are normally used.

According to the corporate offices of a manufacturer of farm machinery, a number of application methods are in use in this industry which are similar to those identified in the automobile industry. This particular company presently uses dip processes for three percent of its products, flow coating for five percent, electrocoating and electrostatic spray for 65 percent, and airless spray methods for the remaining 27 percent. It is rapidly changing to those technologies which improve coating efficiency due to economic considerations of paint wasted and the cost of waste treatment and disposal.

One of the job shop operations surveyed specializes in roll coating flat sheet which is later folded or pressed into a large variety of items from childrens' toys to automobile tags. A second small job shop coats a variety of irregular-shaped items using spray booths and electrostatic disc equipment.

The third job shop surveyed uses dry powder coatings exclusively. This plant has used powder coatings for almost 20 years and has developed a lot of technical expertise in both the electrostatic spray and "fluidized bed" methods. The plant started operation using vinyl coatings only, but now applies epoxy, polyester, acrylic, and nylon powders by electrostatic spray, and epoxy, vinyl, nylon, thermoplastic, and polyethylene coatings by the fluidized bed method.

This plant has also developed the technology which makes it possible to apply multiple layers of powder coatings. This is necessary in order to combine favorable characteristics of different coatings. For example, epoxy coatings may exhibit good adhesion to the surface and good corrosion resistance properties, but provide a poor surface finish which is offset by a top coat of polyester.

In one coil coating operation surveyed, 90 percent of the coatings used in the continuous roll coating processes were thinned with organic solvents and only 10 percent of production was in water-thinned coatings.

However, water-thinned coatings were found to be used in the production of decorative wall paneling. While both of the two plants of this type surveyed still use solvent-based inks for the roll printing of decorative patterns (such as imitation wood grain) and the base for plywood coating, one of the plants uses water-thinned materials for all other layers of the total coating.

The required surface smoothness is obtained with water-thinned coatings by resanding the surface after the application and drying of the initial filler or sealing layers. The desired pattern is then printed on with rolls and the final clear surface layers are also applied by roll coaters. A total of coatings are normally applied.

The other plant has not yet achieved its required surface properties with a complete water-thinned system and uses a solvent-thinned material for the surface layer. Both plants indicated that they would completely eliminate organic solvent from their plants as soon as satisfactory materials are available. Among other advantages this will reduce the high fire hazard in these plants with large quantities of dry plywood and sanding dust.

Other industries which utilize factory-applied coatings are listed in Table 82.

Types of Coatings Used

Types of coatings in use in the surveyed coating operations cover the whole range of products available. These include conventional solvent-thinned coatings, including lacquers, conforming solvent (Rule 66) coatings, water-borne types, high solids liquid coatings, and dry powder coatings. The specific coatings being applied in each industrial facility visited may or may not be typical of that particular industry and many other plants in the same industrial group may use different coatings to achieve similar results. Insufficient data are available from the plant surveys to determine the range of coatings applicable to each industry or the limitations of any particular coating within any given industry.

Wastes as a Function of Application Method

Spray application has, by its nature, a significant solid waste potential. The loss from such operations will run from 20 to 75 percent of the total coating applied, with the majority of such wastes falling in the range of 40 to 60 percent.

Data obtained from five of the surveyed plants on the percentage of paint going to waste from spray application tend to confirm this. Three of these plants reported a 50 percent average loss from a range of spray applications. The others reported a 45-50 percent and a 23 percent loss respectively.

Other application methods generate considerably smaller wastes since nearly all excess paint is captured for reuse. Most wastes arise from clean-up of the equipment following a change of color or coatings. Thus, the losses from these applications are a function of the frequency with which such changes are made and are not related to the amount of coating used. In general, each clean-up of roll and powder equipment results in very little waste, but changes may be made fairly frequently.

In the surveyed plants, the amount of total wastes from roll coating varied from two percent to 10 percent of the weight of purchased coating material. However, this waste includes cleaning solvents and other contaminants in addition to paint wastes. The plant indicating 10 percent uses water-thinned coatings only and a high proportion of the waste was clean-up water. In general, it appears that the paint lost to waste in roll coating operations is less than two percent.

A major dry powder coating operation achieves a coating efficiency of 85 percent. The 15 percent of dry powder not deposited on the product is collected and recycled. Even if the powder does become contaminated with dirt it can normally be reworked into a lower grade of product. This plant reports that less than 0.25 percent of the coating material goes to waste.

In dip coating any paint which drains from articles which have been coated flows back to the dip tank for reuse. However, this process and electrocoating will generate much larger amounts of cleaning wastes at the end of a run than roll and powder equipment, but the runs are usually much longer.

In many of the surveyed plants coating material in the dye tanks is drummed at the end of a production run and stored for reuse when that type and color of coating are required in the future. This means that wastes are generated only from the cleaning of tanks and hangers. The efficiency of dip operations was reported at between 75 percent and 90 percent at surveyed plants while electrocoating operations were reported with efficiencies of 90 to 96 percent. Wet electrostatic spray application processes were reported to have efficiencies of from 70 percent to better than 90 percent. Flow coating allows recycling of overspray and has an overall efficiency of approximately 90 percent.

Quantity of Wastes

Few of the surveyed plants could provide accurate data on the quantities of waste generated from the application of coatings alone. Some plants include wastes from metal cleaning operations which take place prior to the coating along with coatings waste while others did not. In any event, it is impossible to extrapolate the small amount of data acquired to national totals.

Wastes from coatings operations often are only a small portion of the total process wastes from a manufacturing plant. This is pointed up in Table 83 which lists the solid process wastes in a surveyed appliance manufacturing plant. The actual total wastes remaining for disposal after extensive material reclamation, recycling, and some sludge thickening are also shown. Other types of manufacture may produce a similar distribution of wastes with relative quantities of each waste varying depending on the product made and the processes used.

During the survey visits, it was observed that most plants mix their coating wastes with the various other process wastes generated.

These wastes are normally stored in open trash containers on the plant site.

The following estimate of the total national waste stream from the factory application of organic coatings has been made on the basis of percentage loss from each application method.

On the assumption that approximately 60 percent of the factory-applied coatings are applied by spray, in one form or another, and that the wastes from this process constitute between 40 and 60 percent of the coatings applied, it would produce between 300 and 450 million liters (80 and 120 million gal.) of waste per year. On the average, 70 percent is solvent leaving between 115,000 to 180,000 kkg (125,000-200,000 tons) of solid and semi-solid waste. The solvent content either goes up the stack to the atmosphere or to air pollution control equipment.

Total paint wastes from all factory-applied coating operations are estimated at between 115,000 and 216,000 kkg/yr (125,000 and 240,000 tons/yr) on a dry weight basis. The small fraction (between 0 to 10 percent) of waste created by methods of application other than spray coatings account for up to 36,000 kkg (40,000 tons) of waste.

The wastes from spray coatings are usually in one of two forms:

1. Dry paint solids deposited on kraft paper used to line spray booths or collected in air filters.

2. The solid portion of the sludge generated in the treatment of water used in water-wall overspray collection systems.

In most other application systems the coating waste derives from cleaning operations, a portion of which is dry solids scraped off surfaces where it has built up; the remainder is included with solvents which have been used to clean the walls, tanks, or other equipment.

The total waste stream containing paint waste therefore includes large quantities of paper, air filters, wash solvents, wastewater, etc. It is estimated that the paint wastes of between 115,000 to 216,000 kkg (125,000-240,000 tons) per year from organic coatings operations is included in a total waste stream of 300,000 to 1,000,000 kkg (330,000 to 1,100,000 tons) per year. Paint waste from most plants will contain some hazardous constituents as defined earlier in this report. Since this material is included in and, in most cases, inseparable from the rest of the waste stream in waste handling, the entire stream is considered potentially hazardous. Insufficient data are available to estimate the quantities of paint wastes which contain no hazardous constituents but some plants will have no hazardous wastes from coating operations.

Wastes as Function of Materials Coated

In the limited number of survey visits made, no correlation was

TABLE 83

TOTAL SOLID WASTES IN AN APPLICANCE PLANT
kg/day (lb/day)

Waste Material	Generated	Left for Disposal After Reuse, etc.
Steel	39,480 (87,020)	Small (inc. in floor sweepings)
Plastics	870 (1,920)	5 (10)
Corrugated Paper, Etc.	5,450 (12,000)	136 (300)
Containers		
Pallets (nonreturnable)	1,810 (3,990)	23 (50)
Drums (nonreturnable)	95 (209)	60 (133)
Tubs & Hydraulic Oils, Drawing Compounds	550 (1,200)	550 (1,200)
Paints, Thinners, Phosphate Scale	480 (1,056)	480 (1,056)
Processing Sludges		
Wastewater Treatment Plant	4,360 (9,600)	1,810 (4,000)
Strip Salts and Paint	370 (820)	370 (820)
Floor Sweepings, Cafeteria & Office Waste	1,090 (2,400)	1,090 (2,400)
Scrap Purchased Parts	45 (100)	45 (100)
TOTAL	54,600 (120,315)	4,569 * (10,069)

*8.4% Waste Not Recovered

identified between the quantity of waste generated and materials coated. Waste quantities are principally a function of application method and the physical shape of the object being coated. A range of application methods are used for most substrates, the nature of which is only one of a number of factors considered when the application method and coating are chosen.

TREATMENT AND DISPOSAL TECHNOLOGY

The survey visits to factory-applied coatings operations indicate that disposal methods for their wastes are virtually identical to Level I technology for paint wastes. All of the surveyed plants were found to be using landfills as their principal solid waste disposal method. The majority reported using contractors to transport and dispose of this waste, generally the same ones used by paint plants, but some are hauling their own wastes to city landfills.

Of the 13 companies visited, seven do not segregate waste streams so that coating wastes go to a landfill along with other solid wastes. Two companies reported sending some paint wastes to solvent reclaimers and some coatings wastes of two others are incinerated by contractors. One plant which generates small quantities of organic wash solvent waste includes this material with clean-up rags sent to a dry cleaner.

Most companies engaged in factory application of coatings will only enter into disposal contracts with companies who are licensed by local environmental control agencies. No change in disposal technology appears likely in the immediate future unless forced upon the industries by regulation of these practices.

Levels II and III technology cannot be precisely identified here. However, the following observations based on the character of the wastes can be made:

Segregated waste coatings which contain no toxic or flammable constituents are suitable for deposition in a sanitary landfill. Other wastes which contain materials which are considered hazardous should be handled as potentially hazardous wastes. A large portion of these streams can be incinerated with the potentially toxic ash going to a secured landfill. The non-combustible portion of this waste -- e.g., wastewater sludge -- should be dewatered and disposed of in a secured landfill.

COST ANALYSIS

The reported costs for disposal of paint wastes in surveyed plants varied from \$4 to \$110/kkg (\$4-\$100/ton) depending on the nature of the coating material, the disposal method, and the factors included in the cost assessment. The higher values represent the total economic loss to a particular plant due to collection, handling, and disposal of paint wastes while lower figures are simply charges made by landfill operators for depositing solid material in their landfill.

REFERENCES

1. Gleason, M. N., Gosselin, R. E., Hodge, C., and Smith, R. P., Clinical Toxicology of Commercial Products, 3rd Edition, Williams and Wilkens, Co., Baltimore (1969).

2. Federation of Societies for Coatings Technology, Federation Series on Coatings and Technology, Unit 1, "Introduction to Coatings Technology," May (1973)

3. Fuller, W. R., Understanding Paint, The American Paint Journal Co., St. Louis (1965).

4. Parker, D. H., Principles of Surface Coating Technology, Interscience Publishers, New York (1965).

5. Census of Manufactures, Bureau of the Census, U.S. Department of Commerce (1967).

6. Brown, R. A., "The Emerging Technologies, " Paint and Varnish Production, Feb. (1974).

7. Marketing Guide to Paint Industry, Charles H. Kline & Co., Inc., Fairfield, N. J. (1972).

8. Arthur D. Little, Inc., Economic Analysis of Proposed Effluent Guidelines for the Paint and Allied Products and Printing Ink Industries, Draft Report, EPA Contract No. 68-01-1541, June (1974).

9. Printing Ink and Paint Formulating Point Source Categories, Effluent Guidelines and Standards, EPA, Federal Register, Feb. 26 (1975).

10. Preliminary Report 1972 Census of Manufactures, Paint and Allied Products, SIC 2851, MC 72(P) - 28E, March (1974).

11. "Big Decline for Solvent - Thinned Industrial Coatings," Industrial Finishing, Jan. (1974).

12. "Use of New Coatings Systems Skyrocketing, Study Reveals," American Paint and Coatings Journal, Nov. 4 (1974).

13. National Paint and Coatings Association Questionnaire sent to members to develop information for Economic Analysis of Proposed Effluent Guidelines for the Paint and Allied Product and the Printing Ink Industries, A. D. Little, Inc. for EPA, EPA-230/1-74/052, Aug. (1974).

Preceding page blank

14. Southern Research Institute, Waterborne Wastes of the Paint and Inorganic Pigments Industries, EPA - 670/2 - 74 - 050, March (1974).

15. Paint Red Book, Palmerton Publishing Co., New York (1973).

16. U. S. Environmental Protection Agency, Report to Congress, Disposal of Hazardous Wastes, SW-115 (1974).

17. Chicago Society of Paint Technology, "Flash Point of Mixed Solvents," Journal of Paint Technology, Dec. (1969).

18. Federation of Societies for Paint Technology, Federation Series on Coatings Technology, Unit 16, "Dispersion and Grinding," Sept. (1970).

19. National Paint and Coatings Association, Raw Materials Index, Pigment Section, June (1970).

20. National Paint and Coatings Association, Raw Materials Usage Survey for the Year 1972, April (1973).

21. National Paint and Coatings Association, Raw Materials Index, Resin Section, Sept. (1972).

22. Hamilton, A., and Hardy, H. S., Industrial Toxicology, Publishing Sciences Group, Inc., Acton, Mass. (1974).

23. Browning, E., Toxicity of Industrial Metals, Appleton-Century-Crofts, New York (1969).

24. Communication from EPA to National Paint and Coatings Association, June 13 (1973).

25. Faith, W. L., et al., Industrial Chemicals, John Wiley & Sons, Inc., New York (1965).

26. Private Communication (1974).

27. Deichmann, W. B., and Gerarde, H. W., Signs, Symptoms and Treatment of Certain Acute Intoxications, Charles C. Thomas, Springfield, Ill. (1958).

28. National Paint and Coatings Association, Raw Materials Index, Chemical Specialties Section, Aug. (1973).

29. "Sherwin-Williams' Frank Bruhns Talks About the Paint Industry Versus Water Pollution," Paint and Varnish Production, May (1971).

30. National Paint and Coatings Association, Raw Materials Index, Solvent Section, Oct. (1972).

31. Kirk-Othmer Encyclopedia of Chemical Technology, 2nd Edition, Interscience Publishers, New York (1963).

32. TRW Systems Group, Recommended Methods of Reduction, Neutralization, Recovery or Disposal of Hazardous Waste, 16 Vols., EPA Contract Study Report, Aug. (1973).

33. Block. S., Paint and Varnish Wastes, EPA Research Grant R 800189, University of Florida, June 1 (1974).

34. WAPORA, Inc., Compilation of Industrial and Municipal Injection Wells in the United States, EPA-520/9-74-020 (1974).

35. Versar, Inc., Assessment of Industrial Hazardous Waste Practices, Inorganic Chemical Industry, Draft Report, EPA Contract No. 68-01-2246, October (1974).

36. Battelle Pacific Northwest Laboratories, Program For the Management of Hazardous Wastes, EPA Contract No. 68-01-0762, July (1973).

37. Arthur D. Little, Inc., Alternatives to the Management of Hazardous Wastes at National Disposal Sites, EPA Contract No. 68-01-0556, May (1973).

38. Jacobs, M.B., The Analytical Toxicology of Industrial Inorganic Poisons, Interscience Publishers, New York (1967).

39. The Condensed Chemical Dictionary, Reinhold Publishing Corp., New York, (1956).

40. Chatfield, H. W., Varnish Constituents, Interscience Publishers, Inc., New York (1944).

41. Sward, G. C., Paint Testing Manual, American Society for Testing and Materials (1972).

42. Merck & Co., Inc., The Merck Index, Rahway, N. J. (1940).

43. Handbook of Chemistry, 10th Edition, McGraw-Hill Book Co., N.Y. (1961).

44. Sax, N. I., Dangerous Properties of Industrial Materials, Reinhold Publishing Corp., New York (1963).

45. Thienes, C. H., and Haley, T. J., Clinical Toxicology, Lea and Febiger, Philadelphia (1964).

46. Cecil, R. L., and Leob, R. F., A Textbook of Medicine, W. B. Saunders, Philadelphia (1959).

47. Plunkett, E. R., Handbook of Industrial Toxicology, Chemical Publishing Co., New York (1966).

SECTION VIII

GLOSSARY

Acrylic Resin

A synthetic resin made from derivatives of acrylic acid.

Additive

One of a number of materials added to coatings in small amounts to alter one or more of its properties. They include anti-skinning agents, anti-settling agents, anti-sagging agents, levelling agents, etc. Almost always the total concentration of these additives will be less than one percent. Driers are not generally defined as additives.

Airless Spray

A coating application technique in which paint is delivered to a spray gun under very high pressure, without any admixture of air. It is atomized by passage through an extremely fine nozzle.

Alkyd Resin

A synthetic resin made from polyhydric alcohols and polybasic acids.

Automatic Spray

A coating application technique in which air and paint are supplied to the guns under pressure and mixed in the gun. Either the fixed guns or the work may move up and down, or rotate, to obtain complete coverage which is activiated by a switch.

Binder

The film forming ingredient in paint that binds the pigment particles together.

Brushing

A coating application technique primarily used with trade sales paints including industrial maintenance painting. Also used for touch-up, repair, and articles of unusual shape which do not lend themselves to other applications.

Calking

A soft plastic material, consisting of pigment and vehicle, used for sealing joints in buildings and other structures where normal structural movement may occur.

Preceding page blank

Case Goods

In furniture manufacture, pieces such as dressers, chests of drawers, buffets, etc.

Coating

A paint, varnish, lacquer, or other finish used to create a protective and/or decorative layer.

Coil Coating

The uninterrupted application of coating to very long sheets of steel or similar material which are received and/or shipped rolled in coils.

Conventional Spray

A coating application technique in which air is delivered to a spray gun under pressure and mixed with the coating in the nozzle, or just before reaching the nozzle. The paint is atomized by passage through the nozzle into the air.

Curtain Coating (Flow Coating)

A coating application technique in which a thin sheet of coating flows down on the work as it passes, usually from a V-shaped trough. A doctor blade removes the excess paint and returns it to process. Usually used for coil coating.

Diluent

A liquid, usually a petroleum hydrocarbon, which is blended with an active solvent in a paint or lacquer to increase the bulk or reduce the cost.

Dip Coating

A coating application technique in which work is inserted in a tank of coating, removed, and allowed to drain back in the tank. Excess paint, especially the "fatty edge" on the bottom of the piece, may be removed electrostatically. Continuous dip coating, used for flexible materials, such as wires, mesh, cloth, etc., runs the material through a trough of coating and removes any excess by a doctor blade or squeegee.

Drier

A composition which accelerates the drying of oil, paint, printing ink, or varnish. Driers are usually metallic-based compositions and are available in both solid and liquid forms.

Drying Oil

An oil which readily takes oxygen from the air and changes to a relatively hard, tough, elastic substance when exposed to form a thin, dry film. Drying oils also act as binders for pigments used in coatings.

Electrostatic Deposition (Electrocoating)

A coating application technique in which the work is dipped into a dilute coating mixture which is deposited by a process analagous to electroplating of metals. Used largely for primers on automobiles and parts. Also used to apply finishes on some appliances.

Electrostatic Spray

A coating application technique in which the spray nozzle is charged with one polarity, and the work with the other, so that spray is attracted to the work surface. Very high voltage at low amperage is used. Spray particles are attracted to the work by the opposite charge, to the extent that some of the overspray curves back and coats the reverse side of the work. Very largely used for the application of powder coatings.

Enamel

A pigmented coating which is characterized by an ability to form an especially smooth film which is free from brush or other tool marks. Although most enamels are glossy, flat enamels are also available. They are usually considered to be relatively hard coatings.

Extender

A pigment which is usually inexpensive and inert in nature, used to extend or increase the bulk of a paint, thus reducing its unit cost, and modifying its consistency.

Exterior Paint

A coating for the outside surfaces of a structure.

Factory-Applied Coating

A coating which is applied in a manufacturing establishment as part of the operation of making an article of commerce.

Film

Layer or coat of paint or other material applied to a surface.

Fire-Retardent Paint

A descriptive term which implies that the described product, under accepted methods of test, will significantly (a) reduce the rate of flame spread on the surface of a material to which it has been applied, (b) resist ignition when exposed to high temperatures, or (c) insulate a substrate to which it has been applied and prolong the time required to reach its ignition, melting, or structural-weakening temperature.

Flat Finish

Having no gloss or luster.

Fungicide

An agent that helps prevent mold or mildew growth on a painted surface.

Grinding

The incorporation of pigment into the vehicle by shearing and dispersing aggregates of particles in one of a variety of mills. There is usually little or no particle size reduction.

Industrial Coating

A paint used to coat a manufactured product prior to its sale.

Interior Paint

A coating for the inside surfaces of a structure.

Lacquer

A fast-drying clear or pigmented coating that dries by solvent evaporation only. Other types of coatings, by comparison, dry by a combination of evaporation, oxidation, and polymerization of portions of their constituents.

Latex Paint

A paint containing a stable aqueous dispersion of synthetic resin, produced by emulsion polymerization, as the principal constituent of the binder. Modifying resins may also be used.

Marine Paint

A varnish specially designed to withstand immersion in water and exposure to marine atmosphere.

Mildewcide

See Fungicide.

Mineral Spirits

A petroleum derivative used as a thinner for paints and varnishes. It usually boils in the range of 149 to 204° C (300 to 400° F) and has a flash point just about 27° C (100 ° F).

Mixing

The incorporation of ingredients into a coating with the use of little or no shearing energy.

Oil Paint

A paint that contains drying oil or oil varnish as the basic vehicle ingredient.

Overspray

In a spray booth, that portion of the coating sprayed which does not adhere to the work.

Paint

A pigmented liquid composition which is converted to an opaque solid film after application as a thin layer.

Pigment

The fine solid particles used to add color and other properties to paint or printing ink which are substantially insoluble in the vehicle.

Plasticizer

A substance added to paint, varnish, or lacquer to impart flexibility.

Powder Coating

A coating, prepared as a dry powder, which is placed on a surface and fused into a coherent film.

Preservative

Material added to water-thinned paints to prevent the growth of bacteria or yeast in the can during paint storage.

Primer

The first of two or more coats of a paint, varnish, or lacquer system.

Putty

A dough-like material consisting of pigment and vehicle, used for sealing glass in frames, and for filling imperfections in wood or metal surfaces.

Resin

A natural or synthetic material that is the main ingredient of paint which binds the various other ingredients together. It also aids adhesion to the surface.

Reverse Roll Coating

A coating application technique in which the paint is applied to a roll which rotates in the opposite direction from the work, forcing intimate contact of the paint with the surface. Often used for coil coating.

Roll Coating

A coating application technique in which paint is delivered to a roll which rotates in the same direction as the work is moving and, essentially at the same speed. Very similar to printing, and often used for lithography or where designs are to be printed on the surface, as with wood graining of flat surfaces.

Rosin

A resin that is obtained from coniferous trees (usually pine, but also spruce and fir).

Shellac Varnish

A varnish made by dissolving shellac resin in alcohol. Shellac is the form of lac resin obtained in thin curled sheets (shells).

Slush Coating

An infrequently used coating application technique used on large containers. An excess of paint is poured into the container, distributed by rotating the container, and the excess is poured into the next container, and so on.

Solvent

The volatile part of a paint composition that evaporates during drying.

Stain

A solution or suspension of coloring matter in a vehicle designed primarily to be applied to create color effects rather than to form a protective coating. A transparent or semi-opaque coating that colors without completely obscuring the grain of the surface.

Thinner

The portion of a paint, varnish, lacquer, or printing ink, or related product that volatilizes during the drying process. The solvents and diluents which act as thinners are used to reduce coating viscosity, and prevent oxidation, polymerization, and drying prior to coating application.

Tint

A color produced by the mixture of white pigment or paint in predominating amounts with a colored pigment or paint which is not white.

Trade Sales Coating

A paint sold for consumer use in home or for maintenance of commercial structures.

Tumbling

A coating application technique used for small articles sech as buckles, metal buttons, small hardware, etc. The articles, along with sufficient paint to coat them, are placed in a barrel, which is rotated until the articles are uniformly coated. They are then discharged onto a screen which allows the excess paint, if any, to drain off.

Varnish

A transparent liquid that dries on exposure to air to give a decorative and protective coating when applied as a thin film. Varnish may be made by reacting an oil and a resin at high temperature and dissolving in a suitable element (Cooked Varnish), or by blending a previously made resin with a solvent (Cold Blended Varnish).

Vehicle

The volatile and non-volatile liquid portion of a paint or coating which disperses and suspends the pigment whenever the latter is used.

VM&P Naphtha

Varnish Maker's and Painter's Naphtha. A petroleum fraction boiling below mineral spirits and having a lower flash point.

Volatile Fraction

That portion of a coating which evaporates from the film during the drying process.

Work Piece

An object being coated by some method.

APPENDIX A

WAPORA, Inc.
Washington, D.C.
C-36
9/10/74

HAZARDOUS WASTES OF THE PAINT AND ALLIED PRODUCTS INDUSTRY

Plant Survey Report

I. GENERAL INFORMATION

Company Name ______________________________ Date Visited __________

Plant Address ______________________________ Zip Code __________

Telephone ____/______________ Survey Team ______________________

Persons Contacted ______________________________________

EPA Representative Present ______________________________

Plant Age ______________ Plant Employees ______________

Last Major Expansion or Modification ______________________

____

Number of Different Raw Materials Used ________ List Available __________

Products other than Paint & Coatings Manufactured at this Location __________

____

ANNUAL PRODUCTION IN 1000 GALLONS

Products	Trade Sales	Factory-applied Coatings
Water-thinned Paints		
Solvent-thinned Paints		
Clear Varnishes and Stains		
Lacquers (including acrylics)		
Putty and Glazing		
Other (specify)		
TOTALS		

Preceding page blank

COMPANY NAME ______________________ LOCATION ______________________

II. POTENTIALLY HAZARDOUS MATERIALS USAGE

A. Do you use raw materials containing any of the following materials?

Item	Material	Conc.	Annual Usage
Antimony			
Arsenic			
Asbestos			
Barium (other than barium sulfate)	Barium metaborate		
	Other		
Beryllium			
Cadmium	Cadmium pigments		
	Other		
Chromium	Lead chromate		
	Zinc chromate		
	Strontium chromate		
	Lead silico-chromate		
	Chromium oxide		
	Other		
Cobalt	Cobalt drier		
	Other		
Copper	Cuprous oxide		
	Phthalocyanine blue		
	Phthalocyanine green		
	Other		
Cyanide			
Halogenated Hydrocarbons (low volatility)	PCB		
	Other		
Lead	White lead		
	Red lead		
	Lead chromate		
	Lead silicochromate		
	Lead molybdate		
	Lead drier		
	Other		
Mercury	PMO		
	PMA		
	Other		
Pesticides (organic)			
Selenium	Selenium pigments		
	Other		
Zinc (except zinc oxide and zinc dust)	Zinc drier		
	Zinc stearate		
	Zinc chromate		
	Other		
Low Flash Solvents (below 100°F.)	VM&P naphtha		
	Textile spirits		
	MEK		
	Toluene		
	Xylene		
	Other		

COMPANY NAME ______________________ LOCATION ______________________

III. UPSETS AND NON-EQUILIBRIUM CONDITIONS

A. Average Spoiled Batches Per Year Not Returned to Process __________

B. Average Size of Spoiled Batch ______________________

C. Methods Used for Disposing of These Spoiled Batches? __________

____

D. Frequency of Spills Greater Than 5 Gallons ______________________

E. Cause of Spills ______________________

F. Quantities Spilled ______________________

G. Spill Cleanup and Disposal Methods ______________________

____

____

IV. SOLID WASTE DISPOSAL METHODS

A. Are potentially hazardous wastes handled or treated differently from other solid or semi-solid wastes? ____ If yes, explain __________

____

B. Are potentially hazardous solid and semi-solid wastes disposed of on-site or off site? _____ What disposal methods are used? __________

____

C. Disposal method(s) used for water and wastewater treatment sludges?

____

D. Quantity of process wastewater generated ______________________

E. Disposal method(s) used for materials collected by air pollution abatement devices ______________________

____

COMPANY NAME ______________________ LOCATION ______________________

F. Does a private contractor dispose of any of your plant wastes? ____

Contractor Name ______________________

Address ______________________

Phone Number ______________________

Type of Disposal Facility ______________________

Approximate Cost of Disposal Service ______________________

Method(s) Used to Store and Collect Wastes for Disposal (containers used, precautions taken both at plant and contractor's site)

____

____

____

G. How are waste solvents and other organic materials discharged? ____

____

H. How are used containers discarded? ______________________

____

I. What are the quantities of wastes hauled away? ______________________

____

____

V. FUTURE OPERATION CHANGES

A. Are there any firm plans for changing the use of potentially hazardous materials in your process? ______________________

____

____

B. Are there any firm plans for changes in hazardous waste disposal methods? ______________________

____

____

APPENDIX B

DETAILED SIC BREAKDOWNS OF PAINTS AND ALLIED PRODUCTS

28511	Exterior Oil-Type Trade Sales Paint Products
28511 11	Oil and alkyd vehicle paints in paste and semipaste form
	Oil paints, enamels, and varnishes in ready-mixed form:
28511 21	Oil and alkyd vehicle house paints and tinting bases
28511 22	Sash, trims, and trellis enamels and tinting bases
28511 24	Porch and deck enamels and tinting bases including interior-exterior floor enamels
28511 25	Undercoaters and primers
28511 27	Barn and roof paints (excluding bituminous paints and roof coatings)
28511 28	Marine paints and enamels (shelf goods)
28511 31	Metallic paints (aluminum, zinc, bronze, etc.)
28511 32	Traffic paints (all types, shelf goods and highway departments)
28511 33	Automotive and machinery refinish paints and enamels, except lacquers
28511 34	Automotive and machinery refinish primers and undercoaters
28511 35	Varnish, oleoresinous (synthetic and natural)
28511 37	Stains (including shingle and shake)
28511 39	Other exterior oil paints including bituminous paints
28511 00	Exterior oil-type trade sales paint products, n.s.k.
28512	Exterior Water-Type Trade Sales Paint Products, Including Tinting Bases
28512 11	All purpose water emulsion paints and tinting bases (excluding exterior-interior water emulsion paints)
28512 16	Masonry water emulsion paints and tinting bases
28512 19	Other exterior water-thinned paints, including dry types
28512 00	Exterior water-type trade sales paint products, n.s.k.
28513	Interior Oil-Type Trade Sales Paint Products
28513 5	Oil paints, enamels, and varnishes in ready-mixed form:
28513 52	Flat wall paints and tinting bases including semi-paste (oil and alkyd vehicle)
28513 53	Glass and quick drying enamels and tinting bases
28513 54	Semigloss paints and tinting bases
28513 56	Undercoaters and primers
28513 59	Other interior oil paints and enamels, n.e.c., including mill white paints and interior marine shelf goods

NOTE: n.s.k. - Not specified by kind
n.e.c. - Not elsewhere classified

28513 6	Varnishes:
28513 65	Varnishes, except shellac varnishes
28513 67	Shellac varnish
28513 71	Stains
28513 81	Aerosol paints made from paint produced and packaged in this establishment or packaged on contract for you
28513 00	Interior oil-type trade sales paint products, n.s.k.
28514	Interior Water-Type Trade Sales Paint Products, Including Tinting Bases
28514 11	Flat water emulsion paints and tinting bases
28514 21	Semigloss water emulsion paints and tinting bases
28514 31	All purpose water emulsion paints
28514 98	Other interior water-thinned paints including paste and semipaste
28514 00	Interior water-type trade sales paint products, n.s.k.
28515	Trade Sales Lacquers
28515 11	Automotive and machinery refinish lacquers
28515 21	Other trade sales lacquers
28515 00	Trade sales lacquers, n.s.k.
28516	Industrial Product Finishes, Except Lacquers
28516 1	Industrial maintenance paints:
28516 11	Interior (especially formulated coatings for special conditions in the interior of industrial plants requiring protection against extreme temperatures, fungi, chemicals, fumes, etc.)
28516 13	Exterior (especially formulated coatings for special conditions in the exterior of industrial plants requiring protection against extreme temperatures, fungi, chemicals, fumes, etc.)
28516 18	Marine paints, ship bottom and other specially formulated paints (excluding shelf goods)
28516 3	Transportation (original equipment):
28516 31	Automobile finishes
28516 33	Truck and bus finishes
28516 35	Railroad finishes
28516 37	Other transportation equipment, including aircraft, rockets, and missiles
28516 38	Appliance, heating equipment, and air-conditioner finishes
28516 41	Wood furniture and fixture finishes
28516 42	Wood and composition board flat stock finishes
28516 44	Sheet, strip and coil coatings, including sidings (excluding containers)

28516 4	Metal decorating:
28516 45	Container and closure finishes
28516 46	Other metal decorating
28516 47	Machinery and equipment finishes (including road building equipment and farm implements) (excluding insulating varaish)
28516 48	Metal furniture and fixture finishes
28516 51	Paper and paperboard, excluding pigment binder
28516 52	Insulating varnishes, electrical types
28516 53	Powdered coatings
28516 98	Other industrial product finishes (excluding semi-manufactured products such as pigment dispersions and ink vehicles)
28516 00	Industrial product finishes, except lacquers, n.s.k.
28517 --	Industrial Lacquers, Including Acrylics
28517 11	Automotive
28517 21	Wood
28517 31	Fabricated metal
28517 41	Paper and paperboard
28517 98	Industrial lacquers for other end uses
28517 00	Industrial lacquers, including acrylics, n.s.k.
28518 --	Putty and Allied Products
28518 11	Wood and textile preservatives (nonpressure type)
28518 21	Wood filters and sealers
28518 53	Putty and glazing compounds
28518 63	Paint and varnish removers
28518 98	Other allied paint products, including brush cleaners
28518 00	Putty and allied products, n.s.k.
28519 --	Miscellaneous Paint Products
28519 11	Thinners for dopes, lacquers, and oleoresinous thinners, including mixtures and proprietary thinners
28519 41	Aerosol paints made from purchased paint
28519 51	Organosols and plastisols, other than coatings
28519 77	Miscellaneous related paint products, e.g., pigment dispersions, ink vehicles, etc.
28519 00	Miscellaneous paint products, n.s.k.
28510 00	Paints and allied products, n.s.k., for companies with 10 employees or more
28510 02	Paints and allied products, n.s.k., for companies with less than 10 employees

Appendix C

Explanation of Toxicity Ratings Excerpted from *Clinical Toxicology of Commercial Products* (1)

1. The rating is based on mortality, not morbidity -- i.e., it is really a lethality rating. In general, a clinically significant illness may be expected after dose of about one-tenth the probable lethal dose (as the latter is reflected in the numerical toxicity rating).

2. Unless otherwise noted, each rating is based on the acute toxicity of a single dose when taken by mouth. Other dose regimens and other routes of administration are not represented by the rating.

3. The toxicity rating reflects an estimate of the probable or mean lethal dose, not the minimal fatal dose. Perhaps because of personal idiosyncrasy or hypersensitivity or predisposing disease, minimum lethal doses recorded in the literature are usually considerably lower than those implied by the current ratings.

4. With only a few compounds are clinical data adequate to establish a toxicity rating. Most of the values here are based on laboratory determinations of mean lethal doses (LD_{50}) in small laboratory mammals (rat, mouse, guinea pig, rabbit; sometimes cat, dog, and monkey.) Implicit in the use of such data is the conventional assumption that the mean lethal dose in man lies in the same class as does the LD_{50} for the test animals. Whenever available, however, clinical data and even clinical impressions have been given precedence.

5. Toxicity ratings followed by interrogation points are based on obviously inadequate data; some represent no more than "guesstimates."

6. For most corrosive agents, such as mineral acids, alkalies, bleaches, etc., no toxicity rating is suggested. In these cases death is usually the result of severe local tissue injury, with secondary complications such as toxemia, shock, perforation, infection, hemorrhage, and obstructions. The intensity of the local lesion and of its sequela is often determined by the concentration of the corrosive substance, whereas the volume and "dose" are secondary considerations. For such agents no single toxicity rating is an appropriate measure of lethality, unless the concentration is also specified. No simple parameter describes this relation in a way which is thought to be clinically useful.

7. In Table 13 common units of measure are used to describe lethal doses for an adult of average size. For patients who are heavier or lighter, probably lethal doses are proportionately larger or smaller, and they can be readily estimated from values in the table. While we

Preceding page blank

appreciate that infants and children are not simply small adults, reliable clinical data are so scarce that we are forced to assume that except for recognized exceptions lethal doses are proportional to body weight irrespective of age.

8. Although all are based on Table 13, toxicity ratings given in the Ingredients Index have a distinctly different meaning from those in the General Formulations Index. In the latter each rating is an estimate of the toxicity of a complete commercial product as it is marketed. In the Ingredients Index, each rating is a measure of the inherent toxicity of a single ingredient. In establishing the latter toxicity ratings, each dose has been calculated in terms of a single substance (usually technical grade) and is generally based on experiments in which only an innocuous solvent or vehicle was used (such as water, corn oil, etc.) omitting all solvents, additives, and other ingredients found in the usual commercial formulations. Because many of these ingredients are unavailable to the consumer in pure or undiluted form, the toxicity ratings in the General Formulations Index are more realistic in terms of clinical exposure but are inevitably less accurate than those in the Ingredients Index.

APPENDIX D

POTENTIALLY HAZARDOUS MATERIALS
Data Summary Sheets

Molecular Weight	Chemical Name	Common Name	Formula	Appearance	Industrial Use	Specific Gravity	B.P., °C	M.P., °C	Water Solubility, g/100g	Alcohol Solubility, g/100g	Flash Point, °C	Gleason Toxicity Rating	Threshold Limit Value, mg/m³ air
116.16	2-Pentanone-4-hydroxy-4-methyl	Diacetone Alcohol	$(CH_3)_2C(OH)CH_2COCH_3$	Colorless Liquid	Solvent	0.9406	167.1	-44	Miscible	Miscible	[illegible]	3	[illegible]
58.08	2-Propanone	Acetone	CH_3COCH_3	Colorless Liquid	Solvent	0.791	56.2	-94.8	Miscible	Miscible	18	3	[illegible]
46.07	Ethanol	Grain Alcohol	CH_3CH_2OH	Colorless Liquid	Solvent	0.7893	78.3	-112	Miscible	Miscible	13	2	1000
88.10	Ethyl Acetate	Acetic Acid	$CH_3CO_2CH_2CH_3$	Clear Liquid	Solvent	0.902	77.1	-82.4	Slightly	Miscible	4.4	3	400
100.21	Heptane	N-Heptane	$CH_3(CH_2)_5CH_3$	Colorless Liquid	Solvent	0.684	[illegible]	-90.5	Insoluble	Soluble	[illegible]	1	[illegible]
60.11	2-Propanol	Isopropyl Alcohol	$CH_3CHOHCH_3$	Colorless Liquid	Solvent	0.786	82.3	-89.5	Soluble	Soluble	11.7	3	400
32.04	Methanol	Wood Alcohol	CH_3OH	Clear Liquid	Solvent	0.792	64.5	-97.8	Soluble	Soluble	11.1	3	[illegible]
72.12	2-Butanone	Methyl Ethyl Ketone	$CH_3COCH_2CH_3$	Colorless Liquid	Solvent	0.806	79.6	-85.9	Soluble	Soluble	2.2	3	[illegible]
100.16	2-Butanone-3, 3-dimethyl	Methyl Isobutyl Ketone	$(CH_3)_3CCOCH_3$	Colorless Liquid	Solvent	0.8024	[illegible]	-49.8	Slightly	Soluble	23.9	3	5
92.13	Methyl Benzene	Toluene	$C_6H_5CH_3$	Colorless Liquid	Solvent	0.866	110.4	-95	Insoluble	Miscible	4.4	4	[illegible]
106.17	Dimethyl Benzene	Xylene	$C_6H_4(CH_3)_2$	Colorless Liquid	Solvent	0.861	144	-47.9	Insoluble	Miscible	25	4	[illegible]
		Mineral Spirits		Liquid	Solvent	0.74-0.76	150-190	?			40	[illegible]	--
	Benzene	VM & P Naphtha		Liquid	Solvent		100-160	?	Insoluble	Miscible	12.8	3	--
266.34	Pentachlorophenol	Pentachlorophenol	C_6Cl_5OH	Prisms	Wood Preservative	1.978	310	174	Slightly	Soluble	--	4	--
												5	--
323.5	Antimony Pentoxide	Antimony Oxide	Sb_2O_5	Pale Yellow Powder	Pigment	[illegible]	[illegible]	[illegible]	Insoluble	Insoluble	--	5	--
291.5	Antimony Trioxide	Antimony Oxide	Sb_2O_3	Colorless Crystals	Fire Retardant & Pigment	[illegible]	1550	656	Very Slightly Soluble	--	--	5	0.5
339.7	Antimony Trisulfide	Antimony Sulfide Stibnite	Sb_2S_3	Yellow-Orange to Black Crystals	Orange & Red Pigment	4.64	--	550	0.0002 To Decompose	--	--	5	0.5

APPENDIX D, CONT.

POTENTIALLY HAZARDOUS MATERIALS
Data Summary Sheets

Molecular Weight	Chemical Name	Common Name	Formula	Appearance	Industrial Use	Specific Gravity	B.P., °C	M.P., °C	Water Solubility, g/100g	Alcohol Solubility, g/100g	Flash Point, °C	Gleason Toxicity Rating	Threshold Limit Value mg/m³
	Asbestos	Long & Short Fibered Asbestos		Flax-Like Fibers	Binder & Filler		Decomposes	Decomposes	Insoluble	Insoluble			
197.4	Barium Carbonate	Barium Carbonate	$BaCO_3$	White Crystalline Powder	Pigment	4.43	Decomposes	1740 at 90 atmospheres	0.002 to 0.007	Insoluble		5	0.5
491	Barium Lithol	Lithol Red	$(C_{20}H_{13}N_2SO_4)_2Ba$	Pigment	Pigment	1.60	--	--				5	
261.0	Barium Metaborate		$BaB_2O_4 \cdot H_2O$	White Powder		3.25-3.35	--	--					0.5
191.4	Cadmium Selenide	Cadmium Red	CdSe	Gray-Brown or Red Powder	Pigment	5.81	--	>1350	Insoluble			5-6	0.1
		Chlorinated Rubber	$C_{10}H_{11}Cl_7$ (Varies)	White or Cream Powder Fiber or Porous Block	Quick Drying Film Former or Flame Retardant	Varies	--	Varies	Insoluble	Insoluble			
152.0	Chromic Oxide	Chromium Oxide Green	Cr_2O_3	Lt. Green Powder	Pigment	5.21		1990	Insoluble			2	1.0
	Cobalt Naphthenate	Cobalt Drier		Crystal	Drying Catalyst				Insoluble	Insoluble		4	0.1
361.8	Copper Naphthenate	Copper Drier	$Cu(C_7H_{11}O_2)_2 \cdot H_2O$	Light Blue Powder	[illegible] Preservative			[illegible] 150	Slightly Soluble	Slightly Soluble		4	
143.1	Cuprous Oxide	Red Copper Oxide Cuprite	Cu_2O		Pigment (antifouling marine paints only)	6.00	1800	1235	Insoluble	Insoluble		4	
775.7	Lead Carbonate, Basic	White Lead	$2PbCO_3 \cdot Pb(OH)_2$	Heavy White Powder	Pigment	6.14		Decomposes at 400	Insoluble	Insoluble		4	
323.2	Lead Chromate	Chrome Orange or Chrome Yellow	$PbCrO_4$	Yellow Crystals	Pigment	6.30	Decomposes	844	0.000006			4	
367.2	Lead Molybdate	Wulfenite or Molybdate Orange	$PbMoO_4$	Yellow Powder	Pigment	5.01-7.01		1070	Insoluble	Insoluble		4	
223.2	Lead Monoxide	Litharge or Lead Oxide Yellow	PbO	Reddish Yellow Crystals	Varnish Drier	9.53		888	0.001 at 18°C			4	0.15
	Lead Naphthenate	Lead Drier	$Pb(C_7H_{11}O_2)_2 \cdot H_2O$	Crystal	Drying Catalyst	1.16						4	

APPENDIX D, CONT.

POTENTIALLY HAZARDOUS MATERIALS
Data Summary Sheets

Molecular Weight	Chemical Name	Common Name	Formula	Appearance	Industrial Use	Specific Gravity	B.P., °C	M.P., °C	Water Solubility, g/100g	Alcohol Solubility, g/100g	Flash Point, °C	Chronic Toxicity Rating	Threshold Limit Value, [illegible]
811.6	Lead Orthophosphate	Lead Phosphate	$Pb_3(PO_4)_2$	White Powder	Anti-Corrosive Paint for Structural Steel	6.90- 7.30		1014	0.000014 at 20°C	Insoluble		3	
	Lead Silicochromate	Lead Silicochromate		Yellow Powder	Anti-Corrosive Pigment for Structural Steel	4.51						4	
685.6	Lead Tetroxide	Lead Oxide Red Lead	Pb_3O_4	Heavy, Bright Red Powder	Pigment	8.32- 9.16	1472	890	Insoluble	Insoluble		4	
336.8	Phenylmercuric Acetate	PMA	$C_6H_5HgOC_2H_3O$	White Lustrous Crystals	Fungicide Mildewcide Preservative			149	Slightly Soluble	Soluble		5	0.01
	Phenylmercuric Oleate	PMO			Fungicide Mildewcide Preservative				Insoluble			5	
1355.0	Copper Phthalocyanine Chloride	Phthalocyanine Green	$C_{32}H_2N_8Cl_{14}Cu$	Dark Green Powder	Pigment	1.94- 2.05						3	
203.6	Strontium Chromate		$SrCrO_4$		Pigment	3.90			0.12 at 15			4	
	Phenylmercuric Succinate	Superadit®			Preservative Fungicide Insecticide							4	
575.5	Copper Phthalocyanine	Phthalocyanine Blue	$C_{32}H_{16}N_8Cu$	Dark Blue Powder	Pigment	1.54- 1.74				Insoluble		4	
309.04	Tributyl tin Fluoride		$(C_4H_9)_3SnF$	Pale Yellow Liquid	Insecticide							4	
296.8	Zinc Potassium Chromate	Zinc Yellow	$4ZnO\cdot 4CrO_3\cdot K_2O\cdot 3H_2O$	Green, Yellow Prisms	Pigment	3.5			Slightly	Insoluble		4	
307.6	Zinc Naphthenate		$Zn(C_6H_5COO)_2$	White Powder	Fungicide, Mildewcide, Drier				2.6			2-3	
106.39	Zinc Peroxide	Zinc Superoxide	$ZnO_2\cdot 1/2H_2O$	Yellowish Powder	Pigment	3.00			Decomposes	Decomposes		3	
458.11	Zinc orthophosphate tetra-hydrate	Zinc Phosphate	$Zn_3(PO_4)_2\cdot 4H_2O$	White Powder	Pigment	3.03			Insoluble	Insolube		3	
632.33	Zinc Stearate		$Zn(C_{18}H_{35}O_2)_2$	White Powder	Pigment	1.09		120	Insoluble	Insoluble		3	

APPENDIX E

BASIS FOR WASTE CHARACTERIZATION TABLES

Solvent-Thinned Trade Sales Paints

An analysis of all surveyed plants manufacturing almost exclusively solvent-thinned paints revealed the following waste characteristics which were used to construct Table 25.

1. Total waste - 106 metric tons per million liters of paint production (441 tons/million gallons).

2. Hazardous solvents - 3.3 metric tons per million liters of paint production (13.6 tons/million gallons).

3. Toxic chemical compounds - 0.4 metric tons per million liters of paint production (1.7 tons/million gallons).

Based on usage in this classification it is estimated that the toxic chemical compounds include 32 percent lead, 12 percent chromium, 4 percent zinc, 2.2 percent barium, 0.6 percent cobalt, and 1.1 percent of other heavy metals such as antimony, copper, cadmium, mercury, etc.

Water-Thinned Trade Sales Paints

An analysis of eight surveyed plants manufacturing almost exclusively water-thinned paints revealed the following data which were used to construct Table 29.

1. Total waste - 130 metric tons per million liters of paint production (541 tons/million gallons).

2. An insignificant amount of hazardous solvents included with waste from the manufacture of water-thinned paints.

3. Toxic chemical compounds - 58 kilograms per million liters of paint production (0.24 tons/million gallons).

These small quantities of toxic chemical compounds are estimated to include 11 percent barium, 1 percent copper, 1 percent cadmium, and 1 percent mercury.

Preceding page blank

Industrial and Non-Industrial Lacquers

Only three of the surveyed plants which had usable waste data manufactured lacquers exclusively. An analysis of their waste characteristics revealed the following waste characteristics which were used to prepare Table 33.

1. Total waste - 64 metric tons per million liters of paint production (268 tons/million gallons).

2. Hazardous solvents - 4.1 metric tons per million liters of paint production (17 tons/million gallons).

3. Toxic chemical compounds - 20 kilograms per million liters of paint production (170 lbs/million gallons).

These very small quantities of toxic chemical compounds are estimated to consist of 10 percent lead, 4 percent chromium, 5 percent cadmium, 2 percent copper, and 4 percent other elements including antimony, zinc, mercury, and barium.

Factory-Applied Coatings

An analysis of 13 surveyed plants manufacturing almost exclusively factory-applied coatings revealed the following waste characteristics which were used to construct Table 36.

1. Total waste - 101 metric tons per million liters of paint production (423 tons/million gallons).

2. Hazardous solvents - 3.1 metric tons per million liters of paint production (13 tons/million gallons).

3. Toxic chemical compounds - 0.3 metric tons per million liters of paint production (1.3 tons/million gallons).

The toxic chemical compounds are calculated to be 32 percent lead, 12 percent chromium, 4 percent zinc, 2.2 percent barium, 0.6 percent cobalt, and 1.1 percent a combination of antimony, copper, cadmium, and mercury.

Putty and Miscellaneous Paint Products

Because of the diverse nature of operations included in miscellaneous paint production, accurate quantification of waste characteristics was impossible within the scope of this study.

The figures presented in Table 41 for this classification are the wastes of the industry as a whole less those identified and itemized in previous classifications. By this approach the following characteristics were identified:

1. Total waste - 107 metric tons per million liters of paint production (448 tons/million gallons).

2. Hazardous solvents - 2.4 metric tons per million liters of paint production (10 tons/million gallons).

3. Toxic chemical compounds - 0.2 metric tons per million liters of paint production (0.85 tons/million gallons).

While data are insufficient to estimate the composition of the toxic chemical compounds in each state, on a national basis they are estimated to contain 26 percent lead, 18 percent asbestos, 10 percent chromium, 3 percent zinc, and 2 percent barium.

APPENDIX F

PRIVATE WASTE CONTRACTORS AND SERVICE ORGANIZATIONS

	EPA Region	Type of Facility*
Liggetto and Blanchard Trucking 78 Smith Street Portland, Me.	I	L.F.
Laurence Trucking Ashland, Mass.	I	
Ahearin Waste Disposal Chicopee, Mass.	I	P.L.F.
S. Hampton Engineering Co. S. Hampton, Mass.	I	
Wm. Lawrence Rich Road Templeton, Mass.	I	
Hoyt Trucking Co. Newport, N.H.	I	
Clean-All Wind Street Subonk, R. I.	I	
Elizabeth Disposal, Inc. (Subsid. of Browning - Ferris) 714 Division Street Elizabeth, N.J.	II	L.F.
James Crockett Jamestown, N.Y.	II	M.L.F.
Chem-Trol Pollution Services, Inc. Model City, N.Y.	II	S.R., I., P.L.F.

---

* P.L.F. - Private landfill
M.L.F. - Municipal landfill
L.F. - Landfill (Type unknown)
I. - Incineration
S.R. - Solvent Recovery
D.R. - Drum Reconditioner

Preceding page blank

Appendix F - Cont'd.

	EPA Region	Type of Facility*
Shayne Bros., Inc. 1601 W Street, N.E. Washington, D.C.	III	P.L.F.
Pearmon Trash Removal 4 Green Valley Drive Arnold, Md.	III	P.L.F.
Bohager and Sons, Inc. 512 S. Eden St. Baltimore, Md.	III	L.F.
Clarence T. Ryan 2208 Round Road Baltimore, Md.	III	L.F.
Cross Efficient Trash Removal Co. 146 S. Franklintown Road Baltimore, Md.	III	L.F.
Johnson and Speake, Inc. (Subsid. Browning - Ferris) Solley Road Baltimore, Md.	III	L.F.
Robb Tyler, Inc. (Subsid. Browning - Ferris) 66 Street and Pulaski Street Baltimore, Md.	III	L.F.& I.
Browning Ferris Industries, Inc. 10210 Greenbelt Road Seabrook, Md.	III	P.L.F.
Abbey Sanitation Hollywood, Fla.	IV	
Automated Waste Industries, Inc. 7325 N.W. 43rd Street Miami, Fla.	IV	
Henry McFale Miami, Fla.	IV	L.F.
United Sanitation Service 2125 N.W. 10th Ct. Miami, Fla.	IV	
JADCO Box 8832 Greenville, S.C.	IV	S.R.

Appendix F - Cont'd.

	EPA Region	Type of Facility*
Clayton Chemical Co. E. St. Louis, Ill.	V	
United Disposal E. St. Louis, Ill.	V	
Kankakee Industrial Disposal 1370 E. Locust Street Kankakee, Ill.	V	
Apollo Disposal Services 711 N. Pine Street [illegible], Ill.	V	
Industrial Waste Disposal Co. Dayton, Ohio	V	L.F.
Garland Cole 7709 Burnelle Dr. Little Rock, Ark.	VI	M.L.F.
Metro Waste Disposal Little Rock, Ark.	VI	P.L.F.
American Container Services, Inc. 3920 Singleton Blvd. Dallas, Texas	VI	
J. W. Siemonsit and [illegible] [illegible] W. Northeast Highway Dallas, Texas	VI	S.R.
Metroplex Sanitation, Inc. P.O. Box 8068 Dallas, Texas	VI	L.F.
Sonics International, Inc. P.O. Box 46058 Dallas, Texas	VI	
Southwest Environmental Co. 1341 West Mockingbird Lane Dallas, Texas	VI	
Texas Industrial Disposal, Inc. 920 S. Lamar Street Dallas, Texas	VI	L.F.
Estes Service Co. P.O. Box 7985 Fort Worth, Texas	VI	L.F.

Appendix F - Cont'd.

	EPA Region	Type of Facility*
Southwest Cooperative P.O. Box 71 Fort Worth, Texas	VI	D.F.
Bioecology Systems 4100 E. Jefferson Grand Prairie, Texas	VI	
Southwest Disposal Longview, Texas	VI	
Donald Hodge St. Louis, Mo.	VII	
United Disposal, Inc. 1605 North Broadway St. Louis, Mo.	VII	L.F.
Wm. Folson St. Louis, Mo.	VII	L.F.
S.C.A. Services, Inc. Arvada, Colorada	VIII	
Capital City Disposal 2300 Joliet Denver, Colorado	VIII	
Reuben Kimbel Denver, Colorado	VIII	
Rocky Mount Denver, Colorado	VIII	
Roll-Off Service Co. 2310 W. 11th Ave. Denver, Colorado	VIII	
Waste Disposal, Inc. (Subsid. of Browning - Ferris) 3001 Walnut Denver, Colorado	VIII	
Englewood-Littleton Rubbish Co. Englewood, Colorado	VIII	

APPENDIX G

COMPANIES [illegible] WASTE

Name	Address	Waste Disposal Method	Source of Information*
Region I			
Colonial Chemical Co. 401/231-6990	50 Armento Johnston, R.I.	Landfill	W.T.C.
G. M. Gannon Co., Inc. 401/884-6900	1 Div. Warwick, R.I.	-	T.D.
Montvale Laboratories	Stoneham Mass.	-	T.D.
Re-Solve, Inc. 617/995-9511	N. Hixville Rd. New Bedford, Mass.	-	W.T.C.
Silvesim Chemical Corp.	Lowell Mass.	-	T.D.
Solvent Recovery Service	Southington Conn.	-	S.R.C.
Region II			
Ashland Chemical Co. 212/962-7763	60 Park Place Newark, N.J.	-	T.D.
Bell Chemical Co., Inc. 516/437-5200	32 [illegible] Ave. Long Island, N.Y.	-	T.D.
Chemical & Solvent Distillers Co., Inc. 212/274-3339	42-14 19th Avenue Astoria, N.Y.	-	T.D.
Chem-Trol Pollution Serv.	Model City New York	-	E.P.A.
Recycling Laboratories	Syracuse New York	-	T.D.

---

* E.P.A. - E.P.A. list of solid waste disposal contractors
W.T.C. - WAPORA telephone contact
W.S.V. - WAPORA site visit
P.S. - Paint Company Survey
T.D. - Telephone Directory
E.M. - Equipment Manufacturer
S.R.C. - Solvent Reclaiming Contractor

CONTRACT SOLVENT RECLAIMING PLANTS (Continued)

Name	Address	Waste Disposal Method	Source of Information*
General Scientific	New Jersey	-	T.D.
Gold Shield (Div. of Detrex) 201/662-1202	835 Industrial Highway Riverton, N.J.	-	T.D.
Hogan Solvents & Chemicals 201/589-5933	49 Central Ave. Kearny, N.J.	-	T.D.
Marisol Inc. 201/469-5100	123 Factory Lane Middlesex, N.J.	Landfill	W.S.V.
Perk Chemical Co., Inc. 212/WO2-0972	217 S. 1st St. Elizabeth, N.J.	-	T.D.
Scientific Chemical Processing Inc. 201/939-0467	216 Paterson Plk. Rd. Carlstadt, N.J.	Incineration	W.S.V.
Solvents Recovery Serv. 201/925-8600	1200 Sylvan Linden, N.J.	-	W.S.V.
C.P.S.	Old Bridge New Jersey	-	S.R.C.
Swope Oil & Chemical Co. 201/663-2928	8281 National Highway Pennsauken, N.J.	-	T.D.
Region III			
Galaxy	Maryland	-	E.P.A.
Browning-Ferris 301/792-0220	Baltimore, Md.	-	E.P.A.
Region IV			
Gold Shield Solvents 704/372-9280	3114 Cullman Ave. Charlotte, N.C.	Landfill	W.S.V.
Jadco Corp. 803/277-9551	411 W. Washington Greenville, S.C.	Reclaimed	W.S.V.
Groce Laboratories 803/877-1048	Beco Road Greer, S.C.	Incineration & Landfill	W.S.V.

CONTRACT SOLVENT RECLAIMING PLANTS (Continued)

Name	Address	Waste Disposal Method	Source of Information*
Gold Coast Oil Corp. 305/264-2761	2835 S.W. 71st Ave. Miami, Florida	-	T.D.
George Whitesides	Louisville Kentucky	-	S.R.C.
Lammers Inc. 502/845-2453	New Castle, Kentucky	Incineration	W.S.V.
Arisee Chemical Co. 404/942-4332	Huey Rd. Douglasville, Ga.	-	T.D.
M & J Solvents Co. 404/355-8240	1577 Marietta Rd. NW Atlanta, Georgia	-	S.R.C.
C-M Solvent & Material Recycling 615/883-5349	4701 Lebanon Rd. Nashville, Tenn.	-	T.D.
Mid-State Solvent Recovery 615/793-7660	112 Mason Rd. LaVergne, Tenn.	-	T.D.
Region V			
Chemical Solvent Inc. 216/398-9070	3751 Jennings Rd. Cleveland, Ohio	Landfill	W.T.C.
Chemtron Corp. 313/871-8048	35850 Schneider Avon, Ohio		T.D.
Hukill Chemical Corp. 216/233-9400	7013 Krick Rd. Cleveland, Ohio	-	W.S.V.
Obitts Chemical Co. 216/323-3275	P.O. Box 375, 142 Locust St. Elyria, Ohio	Incineration	W.S.V.
Spray - Dyne Corp. 513/738-4031	7535 New Haven Fernald, Ohio	-	T.D.
Inland Chemical	Toledo Ohio	-	S.R.C.
Associated Chemical Co. 513/851-0639	11998 Elkwood Dr. Cincinnati, Ohio	-	T.D.

CONTRACT SOLVENT RECLAIMING PLANTS (Continued)

Name	Address	Waste Disposal Method	Source of Information*
R. H. Oberly Co., Inc. 419/729-4216	3828 Twining Toledo, Ohio	-	T.D.
Gold Shield Solvents 313/491-4550	12886 Eaton Detroit, Mich.	-	T.D.
Gold Shield Solvents 616/454-9267	312 Ellsworth SW Grand Rapids, Mich.	-	T.D.
Organic Chemicals 616/LE4-4921	2539 28th S.W. Grand Rapids, Mich.	-	S.R.C.
Nelson Chemicals	Detroit Michigan	-	P.S.
Thomas Solvent Co. 313/491-6365	7720 W. Chicago Detroit, Mich.	-	T.D.
Chemical Recovery Sys.,Inc. 313/326-3100	36345 Van Barn Rd. Romulus, Mich.	-	S.R.C.
U. S. Chemical Co. 313/778-1414	29163 Callahan Detroit, Mich.	-	S.R.C.
American Chemical Services 219/838-4370	Colfax Ave & C&O RR Griffith, Ind.	Incineration	W.S.V.
Seymour Manufacturing Co. 812/522-4051	G Ave W Freeman Field Seymour, Ind.	Incineration	W.S.V.
Conservation Chemical Co.	Indianapolis Ind.	-	E.P.A.
Hammond Solvents Recovery Service Inc. 219/WE1-5241	241 Brunswick Hammmond, Ind.	-	T.D.
Acme Solvent Reclaiming Inc. 815/397-0289	2915 20th Ave. Rockford, Ill.	-	T.D.
Fisher-Calo Chemicals & Solvents Co. 312/CL4-5222	600 West 41st St. Chicago, Ill.	Incineration	W.T.C.
Rho Chemical Company	Joliet Ill.	-	E.M.

CONTRACT SOLVENT RECLAIMING PLANTS (Continued)

Name	Address	Waste Disposal Method	Source of Information*
Barker Chemical Co. 312/928-5000	700 East 135th Chicago, Ill.	Incineration	W.S.V.
Clayton Chemical Co.	E St. Louis Ill.	-	T.D.
Custom Organics, Inc. 312/247-2828	1445 W. 42nd Chicago, Ill	Incineration	W.T.C.
Refining Products Div. 312/678-1537	4256 Wesley Schlr. Park, Chicago	-	T.D.
Syn-Sol Corp. 312/TA9-4030	1500 W. Kinzie Chicago, Ill.	-	T.D.
Milwaukee Solvents & Chemical Corp. 414/252-3550	N. 59 W. 14765 Bobolink Ave. Menom Falls, Wisc.	-	T.D.
Rogers Laboratories	Milwaukee Wisc.	-	T.D.
Waste Research & Reclamation Co.	Eau Claire Wisc.	-	T.D.
Region VI			
J. R. Siemmoneit 214/241-9531	1900 W. Northwest Hwy. Dallas, Texas	-	P.S.
Western States Refining Co. 214/637-6434	4816 Memphis St. Dallas, Texas	Incineration & Deep Well Injection	W.S.V.
Region VII			
Conservation Chemical Co.	Kansas City Missouri	-	E.P.A.
Conservation Chemical	St. Louis Missouri	-	E.P.A.
Chemical Commodities Inc. 913/782-3200	320 E. Blake Olathe, Kansas	-	T.D.

CONTRACT SOLVENT RECLAIMING PLANTS (Continued)

Name	Address	Waste Disposal Method	Source of Information*
Region IX			
Southwest Solvents 602/252-6838	341 W. Buchanan Phoenix, Ariz.	Landfill	W.T.C.
RHO-CHEM 213/776-6233	425 Isis Inglewood, Ca.	-	W.T.C.
James B. Bachelor Co. 213/698-3547	Whittier, Cal.	-	W.T.C.
Baron Blakeslee 209/591-8237	248 Harbor Blvd. Belmont, Ca.	-	T.D.
Chem-Serv. 209/439-7041	P.O. Box 345 Pinedale, Ca.	Landfill & Incineration	W.T.C.
Davis Chemical Co. 213/269-6961	1550 N. Bonnie Beach Pl. Los Angeles, CA.	-	T.D.
Gold Shield Solvents 213/583-8736	3027 Fruitland Los Angeles, Ca.	-	T.D.
Oil & Solvent Process (OSCO) 213/334-5117	1704 W. 1st Azusa, CA.	-	T.D.
Romic Chemical Corp. 415/324-1638	2081 Bag Rd. Palo Alto, CA.	-	T.D.
Solvent Distilling Serv. 415/286-4338	342 S. 23rd San Jose, CA.	-	T.D.
Region X			
Chemical Processors, Inc. 206/767-0350	Seattle, Wash.	-	W.T.C.
Western Processing Co. 206/852-4350	Seattle, Wash.	-	E.P.A.

APPENDIX H

Properties and Uses of Hazardous Raw Materials

Introduction

Discussions of the properties and uses of raw materials deemed hazardous by the contractor are discussed below. The information used in compiling this appendix was obtained from the literature (31)(38)(39)(40)(41)(42)(43)(44)(45)(46)(47) and not as a result of contractor tests.

First metallic-based materials are covered in alphabetical order. This is followed by a discussion of alcohols, aliphatic hydrocarbons, aromatic hydrocarbons, ketones, and esters. A brief description of miscellaneous raw materials is then presented.

Antimony

Antimony trioxide (Sb_2O_3) and antimony trisulfide (Sb_2S_3) are the two compounds of antimony which have been used as paint pigments. Commonly called antimony oxide and antimony sulfide, neither is widely employed today. Antimony oxide is a white pigment, similar in its properties to zinc oxide. Although at one time it had some use in ordinary white paints, today it is used only in fire-retardant paints to reduce charring. This compound was also used at one time in small amounts for the surface treatment of titanium dioxide to reduce its chalking tendency but available records indicate that this use has been discontinued. Its future use in paints for any purpose appears to be negligible, unless some new advantage is discovered, since it has largely been replaced by better and less expensive pigments. Antimony trioxide has a toxicity rating of 5 and is considered potentially hazardous.

Antimony sulfide, a black pigment, had some use in World War II as a component of camouflage paints where a reflectance in infrared, similar to that of chlorophyll, was required. So far as is known the pigment has not been manufactured or used in this country since. It is not considered a hazardous material since no adverse effects were experienced during a gross industrial exposure to this antimony compound (22).

Asbestos

"Asbestos" is defined as the fibrous form of one of a number of minerals, such as actinolite and tremolite (forms of amphibole), chrysolite (a serpentine form and commonest U.S. type), amosite, crocidilite, and anthophyllite. Some of these exist in both the fibrous and nonfibrous forms, and the same term is used for both. In other cases, there is one name for the mineral in the fibrous form and another for the nonfibrous. The hazard is associated with the fibrous form.

Asbestos is used widely for insulation, fire-resistance, and heavy trowelling coatings, but rarely in conventional paints. The principal use in coatings is for asphalt-asbestos roof coatings and calking compounds which do not fall within the scope of this project.

A product containing very short fibers not suitable for most asbestos uses, and a good deal of nonfibrous material, is often sold, at an attractive price, under names such as "asbestos shorts," "asbestos float," or "short-fibered asbestos." This material is commonly used in coatings as is talc, which contains no fibrous material. The latter is frequently referred to as "asbestine,"* a trade-mark International Talc Company used at one time for all of its talcs, whether or not they contained any fibrous material. This term was still employed at many surveyed plants to report the use of talc which is not subject to EPA's National Emission Standard for Asbestos (24).

For purposes of this study, all forms of asbestos containing fibrous material are considered potentially hazardous.

Barium

Four barium compounds have been used in paints. These are barium sulfate, barium carbonate, barium metaborate, and barium lithol.

Barium sulfate is a non-hazardous, inert, and insoluble pigment material with a toxicity rating of 1 (1).

Barium carbonate is a natural mineral, occurring largely in the form of witherite in Great Britain, where it has been used as a paint pigment extender for many years. Small amounts were utilized in the United States in the past to adulterate white lead. The latter pigment was considered the best available and many painters judged the merit of a paint on its weight per gallon since white lead is much heavier than most of the other components of paint. Barium carbonate with a specific gravity fairly close to that of lead carbonate (white lead) could be substituted unnoticed for a portion of the more desirable compound. This use has virtually disappeared.

---

*Use of a trade name does not consitute endorsement of a product.

Barium carbonate must be imported at considerable expense and, while its use was reported by two surveyed plants belonging to the same company, it is not felt that this is a very widespread practice. It is extremely toxic (1) at low dosage, although its acute toxicity varies widely in effects among subjects (25)(1) For this reason, it is variously assigned a 3, 4, or 5 toxicity rating, any of which classifies it as potentially hazardous.

Barium metaborate is a white pigment of very low hiding power, but with considerable mildewcidal, or mildewstatic effect, and may replace mercurials in certain uses. While it is considered perhaps the least hazardous of microbiocides used in paints and has no cumulative effect, evidence of some acute toxicity (26) and the absence of a toxicity rating places this compound in the potentially hazardous category. Since no references were found on the toxicity of barium lithol, it has been treated as potentially hazardous.

Cadmium - Selenium

Cadmium appears in a few, highly specialized paints in the form of pigments ranging from cadmium sulfide (CdS), which is yellow, through a series of cadmium sulfoselenides (CdS_xSe_{1-x}), which are orange, to cadmium selenide, ($CdSe$), which is red. These pigments are more widely used in printing inks and plastics.

No references on the toxicity of these specific compounds were found, so they have been considered as potentially hazardous throughout this study, based on the toxicity of other cadmium- and selenium-based compounds.

Chromium

The principal compounds of chromium used in the paint and coatings industry are lead chromate, lead silico-chromate, zinc yellow (zinc tetroxychromate, sometimes referred to as "zinc chromate"), strontium chromate, chromium oxide, and hydrated chromium oxide (sometimes referred to as "chromium hydroxide" or "chromium hydrate"). "Chrome green" is a mixture of lead chromate and iron blue.

Zinc yellow ($4ZnO.4CrO_3.K_2O.3H_2O$) is used in anti-corrosive primers, usually in alkyd vehicles. It requires a high degree of surface preparation (removal of rust, etc.) and is usually used as a component of factory-applied coatings. Where such surface preparation is not possible, as on structural steel, red lead primers are preferred. Strontium chromate ($SrCrO_4$) is used as a component of "wash primers," which are nearly all factory-applied.

Chromium oxide (Cr_2O_3) is a dull olive green which is very insoluble and heat-resistant. It is the only green which is usable in ceramic materials which must be fired at high temperatures. Hydrated chromium oxide is a similar pigment with a cleaner and brighter green color, but its relatively low hiding power restricts its use.

The availability of phthalocyanine green ($C_{32}H_2N_8Cl_{14}Cu$) in a range of shades has greatly reduced the use of chrome green, which has always been unsatisfactory from the point of view of color retention. Since it is made of two colors (blue and yellow), one nearly always fades faster than the other, so that chrome green changes towards either blue or yellow (usually yellow) on aging.

Chromium oxide has a toxicity rating of 3 and zinc chromate a rating of 4 (1); no reference was located on the toxicity of strontium chromate, hydrated chromium oxide, and phthalocyanine green, thus all of these compounds are considered potentially hazardous.

Lead chromate and lead silico-chromate are discussed below under "Lead."

Cobalt

The significant use of cobalt in the paint industry is as a drier added to drying oils, such as linseed, and oil-derived products, such as alkyd resins. These products require some drier unless they are baked at fairly high temperatures. Cobalt drier is nearly always a component of the drier used, since it gives quick "top dry" and freedom from surface tack. The amounts used are in the catalytic range and usually are less than 0.1 percent of the oil or alkyd component.

Cobalt is also an ingredient of certain ceramic pigments. These are rarely used in the paint industry because of their high cost, but they may have occasional use in high-heat-resistant paints.

Specific information on the toxicity of cobalt naphthenate, the common cobalt drier, is unavailable (1). It is thus considered as potentially hazardous.

Copper

Copper enters paint and coatings largely in the forms of cuprous oxide (Cu_2O), metallic copper, copper naphthenate ($(C_6H_{10}COO)_2Cu$), phthalocyanine blue ($C_{32}H_{16}N_8Cu$), and phthalocyanine green. The phthalocyanines are not classified as cyanides.

Cuprous oxide and metallic copper are important ingredients in anti-fouling paints, but neither is used in significant quantities in any other paints. Copper naphthenate is commonly used in wood preservatives. These are generally used as impregnants, rather than coatings, and, in general, should not fall under SIC 285. However, some are made by paint companies and may be reported as coatings.

Phthalocyanine blue and green are bright pigments, used generally in any coating where their color is required. They have very high tinting strength, so only small amounts are necessary to achieve most of the desired colors. Used as solid colors they are almost black. Their high cost also encourages the use of as little as possible.

Cupric oxide may appear in small amounts as a contaminant of cuprous oxide, but does not contribute to the anti-fouling characteristics, and is generally regarded as useless. It is used in some ceramic colorants, but little, if any, of this enters the coatings industry.

If sufficient heat is applied in the preparation of cuprous oxide, it is virtually insoluble, and in this state is classed as slightly toxic, a rating of 2; a more soluble form, however, is very toxic, with a rating of 4. It is thus considered hazardous.

The toxicity of metallic copper similarly depends on its physical state. As a very fine dust it will go into solution very rapidly and in this form is highly toxic. The form used in paint is a flake which is not readily soluble. However, in the absence of definitive information to the contrary, it is considered potentially hazardous.

Copper naphthenate has a very low order of toxicity according to one source (27), but is tentatively rated as 3 by Cleanson (1). Thus, this compound is also considered potentially hazardous.

Lead

The passage of the Lead Based Paint Poisoning Prevention Act was stimulated in large measure by the lead poisoning of children who ingest old paint films containing quantities of white lead and soluble lead salts. The 1973 amendments to the Act established an 0.5 percent limit on the lead content of paint and required a further reduction to 0.06 percent unless the Consumer Product Safety Commission certified another level as safe. The Commission recently upheld, after mandated research, the 0.5 percent level.

LEAD CHROMATE (Chrome Yellow and Chrome Orange): The formula for normal lead chromate (medium chrome yellow) is $PbCrO_4$. The more orange shades contain some lead hydroxide and reach basic lead chromate, $Pb(OH)_2CrO_4$, the standard "Chrome Orange." Green shades of chrome yellow, often called "Primrose," contain lead sulfate, with the lead chromate decreasing to as little as 57 percent.

These inorganic products account for more than half the total lead used by the paint industry. Far and away the largest use is in yellow traffic paints for which chrome yellow is chosen for its brightness, good hiding power, and durability. Small amounts are also used for other purposes where a bright, durable yellow or orange is required, such as on school buses and certain gasoline stations.

There is, currently, no really adequate substitute for chrome yellow in its typical uses. A bright, clean yellow may be made from nickel titanate, but it is more expensive than chrome yellow, and, unless demand created a larger supply, current production in the United States would probably supply not more than half the total needed for traffic paints alone. There are organic pigments which give the same general color, but their hiding power is low, requiring much larger quantities, and their exterior durability is not good. Too, the traffic paints purchased by municipal, state, and federal governments must conform to composition specifications which call for the use of lead chromate. Thus, the use of chrome yellow may be expected to continue for the foreseeable future.

Chrome orange is used today only in small quantities. It will undoubtedly be replaced if an orange pigment with similar hiding power and durability is found.

Molybdate red (or orange), $PbMoO_4$, is a lead chromate containing some lead molybdate. The pigment becomes redder with increasing quantities of the latter. Only very small amounts are used in the paint industry; it is largely used as a printing ink component.

Because of its greenish-yellow color, Primrose yellow (tinting yellow) was formerly used as the yellow component of chrome green (a mixture of chrome yellow and iron blue). Chrome green has now been largely superseded by phthalocyanine green.

According to one source, the chromates used in paints are insoluble and have created no particular health problem (22) although Gleasor, et al. (1) assign lead chromate a toxicity rating of 4. Lead chromate is thus considered potentially hazardous as are lead sulfate, chrome orange, chrome green, and molybdate red on which no references were found.

RED LEAD AND LEAD SILICO-CHROMATE: These materials, Pb_3O_4 and $Pb(SiO_2)(CrO_4)$ respectively, are anti-corrosive pigments and produce the best and, in many cases, the only satisfactory primers for structural steel for buildings, bridges, etc. Specifically, there are no other adequate pigments where structural considerations prevent first-class surface preparation.

Lead silico-chromate is a recently developed pigment which is superior to lead chromate as an anti-corrosive primer and is more economical; it has thus replaced the latter for this purpose and its use is likely to expand.

Red lead is the more advantageous pigment when structural considerations prevent adequate removal of rust and mill scale. In the future, this pigment may lose some of its market to lead silico-chromate, but it is so thoroughly embedded in federal, state, highway, and railroad specifications that the change will not take place very rapidly.

While no detailed text was found on the toxic effects of red lead and lead silico-chromate, they are both assigned a moderate toxicity rating of 3 which classified them as potentially hazardous.

LEAD DRIERS: Lead driers are compounds of lead with organic acids (rosin, naphthenic, 2-ethyl hexoic, etc.). The lead is the drying catalyst and the effectiveness of the driers depends entirely on the lead content. The organic portion of the molecule contributes solubility in organic solvents. These driers are used in oil, oleoresinous, and alkyd coatings. The lead gives "through-dry" which builds up the ultimate hardness of the film. About 0.1 - 0.2 percent lead is usually required to be effective, which is well within the 0.5 percent legal limit on lead. Lead naphthenate is tentatively assigned a moderate to very toxic rating (1), 3 to 4, either of which is considered hazardous.

OTHER LEAD MATERIALS: White lead (basic lead carbonate), $2PbCO_3.Pb(OH)_2$, basic lead sulfate, $2PbSO_4\ Pb(OH)_2$, or basic lead silicate, $2PbSiO_3\ Pb(OH)_2$, are white pigments which have almost disappeared from modern paints, largely for economic reasons, although, in many cases, their performance is also inferior to that of more modern pigments containing little or no lead. Basic lead silicate is used by a few manufacturers in coatings designed for application to redwood and western red cedar because it appears more resistant to staining from the water soluble dyes in these substrates than other pigments. Other lead compounds have been used as stabilizers in certain resins but they have been largely superseded by other materials which perform as well and cost less. Litharge (lead monoxide) was formerly used for the manufacture of lead driers when driers were made by cooking rosin or some other organic acid with a metallic oxide, carbonate, or acetate. It is presently mixed with glycerin and employed as a fast-setting (and very brittle) cement. It is too reactive to be used as a component of conventional paints.

Lead carbonate is probably responsible for lead poisoning in painters as well as in children who eat old peeling paint films. The dust also presents a hazard (22). Litharge has a toxicity rating of 3 to 4. No specific information was found on the toxicity of lead sulfate and lead silicate. Thus, all of these lead compounds are considered potentially hazardous.

LEAD STABILIZERS: Small amounts of lead compounds are used as stabilizers for resins, particularly polyvinyl chloride. The NPCA Chemical Specialties Index (28) lists 27 lead stabilizers vs. approximately 150 non-lead. High cost, color problems, and other reasons apparently are reducing the lead usage in this area. Toxicity is not at issue since many of the replacements are potentially toxic cadmium or barium salts.

Mercury

The significant use of mercury in the paint industry is as a preservative in water-thinned paints, or as a mildewcide in either water-

or solvent-thinned paints when their exposure is apt to invite mildew. Mercury is usually in the form of phenyl mercury acetate (PMA), phenyl mercury oleate (PMO), or some similar material utilizing higher molecular weight compounds, such as cresyl. The quantity of mercury is usually less than 0.1 percent of the total solids.

At one time, due to a shortage of cadmium, certain red and yellow pigments based on mercuric sulfide were marketed, but it is understood that these are no longer available.

The future of mercury in the manufacture of paint is uncertain due to proceedings under the Federal Pesticide Act. If the EPA Administrator sustains an order to prohibit the manufacture of mercurials, no mercurials will be available to paint manufacture and the mercury content of its wastes will be, effectively, zero. If the cancellation of registration is withdrawn, the usage of mercury will be somewhat higher than might be extrapolated by normal growth, since some manufacturers have discontinued the use of mercury with the expectation that the supply will be soon cut off. If this does not happen, some of them, at least, will return to the use of mercury.

A number of non-mercurial biocides have been developed and are being tested in production (29). At the moment, the general consensus within the paint industry is that they are more expensive and less satisfactory than the mercurials. If, in time, some of the problems associated with these materials are overcome, they could very well displace some mercury use, since mercury has some disadvantages. How soon this may happen, and to what extent, are unpredictable factors at this time.

PMA has a toxicity rating of 5 (1). although there have been no authenticated cases of occupational poisoning related to phenyl mercurials (1)(25). PMA is defined as potentially hazardous as well as PMO on which no specific toxicity reference was found.

Zinc

The following compounds of zinc are used to some extent in the paint industry -- zinc oxide, leaded zinc oxide, lithopone (a mixture of zinc sulfide and barium sulfate), zinc sulfide, zinc dust (metallic zinc), zinc yellow (zinc tetroxychromate), zinc phosphate, zinc naphthenate, and zinc stearate. Various other zinc compounds may be used in very small or trace amounts.

Zinc oxide is a white pigment, used in paints to contribute hiding power and improve the hardness, chalk retention, and mildew resistance of titanium dioxide. It is rated 2 to 3 on the toxicity scale and is thus classified as non-hazardous since it does not meet the criteria used in this report of a rating of 3 or greater.

Leaded zinc oxide is a mixture of zinc oxide and basic sulfate white lead. Contents of five, 35, and 50 percent white lead are most common. Very little is manufactured at the present time. The hazard associated with these pigments arises from the lead content.

Lithopone (and pure zinc sulfide) are white pigments with many of the properties of titanium dioxide, but they are inferior to TiO_2 in color retention and exterior durability. As far as can be ascertained, none are currently manufactured in the United States, primarily because of the lower cost of TiO_2, but some is imported from Europe. Lithopone is a stoichiometric mixture of zinc sulfide and barium sulfate. Neither compound is toxic; it is therefore assumed that the combination is similarly low in toxicity and thus non-hazardous.

Zinc dust is powdered metallic zinc, used primarily as an anti-corrosive primer in areas such as drinking water systems where lead and chromium are ruled out for toxicity reasons. Zinc dust paints are often referred to as "liquid galvanizing." This is not a toxic material and is considered non-hazardous.

Zinc phosphate is a recently introduced pigment which has some use in anti-corrosive paints. No information was found on its level of toxicity so it is treated as potentially hazardous.

Zinc naphthenate (and some other organic zinc compounds) are used, in small amounts, as driers, usually supplementing cobalt. Zinc stearate is a white powder, transparent in most coatings, which is used in sealers and furniture finishes to improve their sanding properties. It has a toxicity rating of 3 (1)(23), which classifies it as hazardous. Zinc naphthenate has a low acute oral toxicity and is rated less than 3 (1). It is thus classed as non-hazardous.

Zinc yellow is discussed under "chromium."

Alcohols

The alcohols commonly used in the paint industry include: methanol (methyl alcohol, wood alcohol) which flashes at 13°C (55°F); ethanol (ethyl alcohol, grain alcohol), 16°C (60°F); isopropanol (isopropyl alcohol, rubbing alcohol), 18°C (65°F); n-propanol, 27°C (81°F); secondary butanol, 23°C (73°F); isobutanol, 29°C (85°F); n-butanol, 37°C (99°F); and numerous other higher alcohols, all flashing well above 38°C (100°F).

Methanol, due to its toxicity, is rarely used as a solvent by the paint industry. Other alcohols are used, sparingly, as solvents for shellac, a few other spirit-soluble resins, and for spirit stains, which are becoming less common. Most of the alcohols used by the paint industry are employed as ingredients of non-paint products such as chemical raw materials in the manufacture of resins. In small amounts, they are also used as part of the solvent blend in lacquers.

The toxicity rating of most of these materials is 3 (1). Therefore, those flashing above 27°C (80°F) which are not defined as hazardous due to their flammability are so designated because of their toxicity.

Aliphatic Hydrocarbons

Aliphatic hydrocarbons are all selected fractions of the distillation of crude oil. Very narrow boiling ranges are usually indicated by the predominant component, although almost all those used as solvents for paint manufacture are mixtures of various parrafins and naphthenes, and many contain significant amounts of armoatics. For various reasons, the olefin content is very low, almost always below two percent.

Pentane, hexane, heptane, and octane, in commercial grades, are all narrow-boiling range materials, but usually contain a mixture of isomers and substantial quantities of naphthenes. Wider-range materials are sold under various terminology, such as textile spirits, rubber solvent, V&MP naphtha, mineral spirits, etc., or are sold under trade names, such as "Varsol."* Pentane, hexane, rubber solvent, and textile spirits usually flash below 0°C (32°F). Heptane and VM&P naphtha flash around 10°C (50°F), and mineral spirits and many trade name products flash above 38°C (100°F).

Aliphatic hydrocarbons are the cheapest available organic solvents, and are invariably used with materials which can be dissolved in them. These include drying oils, many alkyds, and many phenolic varnishes. In general, lacquers and chlorinated rubber, as well as short-oil aklyds and varnishes, are not soluble in aliphatics. The selection of the particular aliphatic to be used depends upon the boiling range required (which determines the flash point), and other properties required by the user.

These substances are also generally assigned a toxicity rating of 3 which places them in the hazardous category (1) regardless of flash point.

Aromatic Hydrocarbons

The common "pure" aromatic hydrocarbons used in the coating industry are toluene which flashes at 4°C (25°F) and xylene, 27°C (81°F). Small amounts of benzene may be used, but this is discouraged by its high toxicity. It is employed primarily in the coatings industry as a chemical raw material, rather than a solvent.

---

*Use of a trade name does not constitute endorsement of a product.

Aromatic hydrocarbons may be derived from petroleum or from coal tars as a by-product of coke production. In the case of petroleum hydrocarbons, the impurities are usually aliphatic and naphthenic hydrocarbons. In the case of coal tar, they are more likely to be other closely-boiling hydrocarbons. Aromatic solvents with a higher boiling point (and higher flash point) than xylene are usually a complex mixture of materials and are sold under a variety of trade names, such as "Solvesso."*

Aromatic hydrocarbons are better solvents for many resins than are the aliphatic hydrocarbons, and are widely used where the resin is difficult to solubilize in aliphatic hydrocarbons, as is the case with short-oil alkyds and phenolics, chlorinated rubber, etc. They are also better diluents for lacquers than the aliphatic hydrocarbons and are largely used for this purpose.

Toluene carries a 4 toxicity rating and xylene a 3 and are therefore potentially hazardous.

Ketones

The ketones commonly used by the coatings industry and their flash points are: acetone, -15°C (5°F); methyl ethyl ketone (MEK), -6°C (22°F); methyl isobutyl ketone (MIBK), 23°C (74°F); mesityl oxide, 29°C (84°F); methyl n-butyl ketone, 27°C (80°F); diacetone alcohol, 54°C (130°F); methyl isoamyl ketone, 41°C (106°F); and isophorone, 93°C (200°F). These are the reported flash points of commercial products, and may differ from the flash point of a pure material. The solvents section of the NPCA Raw Materials Index (30) lists about ten others that are used in small amounts.

Ketones are generally used in lacquers, and usually in a mixture with other solvents. They are strong solvents for many of the binders used in lacquers (nitrocellulose, acrylics, vinyls, etc.). However, they are expensive and have a rather strong odor, and no more is used than is required for the solvency. The choice of individual ketone depends upon the drying rate, levelling, and other properties required for a specific lacquer.

The principal literature found on the toxic characteristics of ketones was directed to acetone, MEK, and MIBK. Acetone appears to be the most innocuous of the three, and MIBK the most toxic, although all three are assigned a rating of 3 (1)(22)(27)(31). They are all considered hazardous both because of their toxicity and flammability.

---

*Use of a trade name does not constitute endorsement of a product.

Esters

Esters are reaction products of an alcohol (ethanol, isopropanol, etc.) and an organic acid (acetic and isobutyric are the commonest.) They are used for much the same purposes as the ketones, but are slightly more pleasant in odor and somewhat more expensive than the corresponding ketones. One or the other may be the choice, depending upon the particular resin blend being used.

The most commonly used esters are ethyl acetate, 1°C (30°F); isopropyl acetate, 16°C (60°F); and the various butyl acetates, 29°C (85°F). Butyl acetates may be normal or isobutyl. Many other esters are available, but they are used in small amounts, and all have higher flash points than are considered hazardous.

Ethyl acetate is relatively innocuous and non-hazardous with a toxicity rating of less than 3 (1) while butyl acetate carries a rating of 3 which places it in the potentially hazardous range of 3 or above. No information was found on isopropyl acetate, so it is not considered hazardous.

Miscellaneous Compounds

There are a few materials listed in Table 20 which do not fall into any of the above groups of materials. These include chlorinated rubber, chlorinated paraffin, and tributyl tin fluoride.

Chlorinated rubber and chlorinated paraffin are high polymer halogenated hydrocarbons. No data on their toxicity were found, which under the criteria applies in this study would classify them as potentially hazardous. However, in view of their use in coatings for water tanks information attesting to their safety must have been developed and so far as is known, no hazardous qualities have been attributed to these compounds.

Tributyl tin fluoride is used almost entirely as a barnacle killer in ship bottom paints. A toxicity rating of 4 is applied to tributyl tin compounds generally, and the use to which the fluoride is put appears to support at least this rating for the particular compound.

μσ1317